# AN INTERACTIVE HISTORY AND GEOGRAPHY OF MEXICO USING MAP OBJECTS FOR JAVA

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in

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_____

by

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**SAN DIEGO STATE UNIVERSITY**

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# DEDICATION

I would like to dedicate this thesis work to my family. Especially my parents for their love, endless support and encouragement in everything that I have ever decided to take on and for being always there for me, in the good and the bad times.

# ABSTRACT OF THE THESIS

An Interactive History and Geography of Mexico Using Map Objects for Java
by
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Master of Science in Computer Science
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Mexico is a country rich in history, culture, traditions and biodiversity, among other things. The motivation for this thesis project comes from the desire to show the user of this application some of this country's richness.

The multimedia application developed as part of this work will cover a general overview of Mexico's Pre-Hispanic period when Mesoamerica (a region and culture area in the Americas that extended from Central Mexico to Belize, Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica) developed and flourished (2000 BC – 1519 AD). This period included the Olmec, Mayan, Aztec civilizations, among many others, that rose and fell leaving behind an incredible amount of contributions to today's Mathematics, Physics, Astronomy, Arts, etc.

The application will provide a couple of interactive maps of Mexico showing the areas covered by the Mesoamerican cultures and relevant information about each of them. It will also provide maps showing the location of the main mountain peaks, ranges and bodies of water in the Mexico of today.

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Finally, I would also like to thank Professor Michael E. O'Sullivan and Dr. Joseph Lewis for agreeing to be part of my Thesis Committee and for taking the time to read this work.

# CHAPTER 1

# INTRODUCTION

The purpose of this thesis work is to provide an interactive bilingual learning tool of Mexico's Pre-Hispanic history and physiography for English and Spanish speaking high school and college students. Due to the younger generation's exposure to a great deal of technology, students in today's world crave a change in the learning processes that are available to them. These processes should include multimedia material and a greater interaction with technology that facilitates and enriches their learning experiences. The aim of this work is to contribute to that learning experience and make it more enjoyable and fulfilling.

Some of the key features the application, developed as part of this project, provides are: the ability to switch between languages (English and Spanish) at any time, not only when the application first runs. Another feature that supports the bilingual part of this tool is the inclusion of sound files that will help, especially the non-native Spanish speakers, pronounce the name of the presented map features (like the Mesoamerican archeological sites). Most of the maps included, as part of this application, use several icon images that facilitate to the user the location of a certain feature on the map. Two dynamic timelines are also made available in this tool to make it easier for the user to better understand and assimilate the events in the key time periods of Mesoamerica's history.

This application was developed as a Geographical Information System (GIS) in order to present to the user different types of geographical data in the form of interactive maps. This allows the possibility to create dynamic searches, based on user queries, to spatial data.

This thesis document contains 7 chapters. In these, all the steps followed in the development process of this application are discussed in detail, from the collection of the software requirements, the data gathering, and the implementation to the conclusions and future work.

In the second chapter of this document, “Technologies Used”, all the technologies used in the implementation of the tool will be listed and briefly described, highlighting the main reason why they were chosen.

The third chapter, “Software Requirements”, will go over the methodology followed for the collection of the requirements for this project. It will list, describe and classify all of them.

The fourth chapter, “Data Collection and Analysis”, will cover the tools and methods used for the collection and preparation of the data used to create all the map layers presented in this application.

The fifth chapter, “Software Implementation”, talks about how each part of this tool was implemented. It contains several screen shots and some code snippets that will guide the reader in the understanding of this process.

The last two chapters of this document, “Conclusions and Obstacles” and “Future Work”, will include lessons learned during this process, the multiple obstacles or difficulties found in the implementation stage and possible future enhancements to the developed application as well as areas of research.

# CHAPTER 2

# TECHNOLOGIES USED

For the development of this project some of the core technologies used were:

- *Programming language:* Java Platform, Standard Edition. Java SE 7u2 (1.7.0_02 version) [1].
- *Application Programming Interface:* MapObjects Java Edition (MOJO23).
- *Web Technologies*: HyperText Markup Language (HTML), Cascade Style Sheets (CSS) and JavaScript.
- *Integrated Development Environment (IDE):* NetBeans.

In the next few sections each technology will be briefly described along with the reasons why it was chosen.

## 2.1 JAVA SE (STANDARD EDITION)

Java is a programming language that derives much of its syntax from C and C++ but has a simpler object model [2]. Java applications are typically compiled to bytecode (class file) that can run on any Java Virtual Machine (JVM) regardless of computer architecture. This means that code that runs on one platform does not need to be recompiled to run on another [2]. This platform independence feature makes this language ideal for the development of this project.

Java is licensed under the GNU General Public License therefore making it free/open source software and a very cost-effective option.

Another advantage of using this language for the development of this project, is how easy is to deploy Java applications. Java uses the Java Archive (JAR) file format which enables you to bundle multiple files in a single archive file that contains all the class files (compiled code) and all the auxiliary resources associated with your application [3]. This JAR file format also allows you to digitally sign the contents for security, especially when downloading from the internet. Most importantly, it eliminates the need to use a windows installer, which keeps your application portable.

## 2.2 MapObjects Java Edition (MOJO23)

This API for Java is a product of ESRI (Environmental Systems Research Institute), headquartered in Redlands, California [4].

The version used for this project was 2.3. This package version contains several libraries developed in Java that a programmer can use to create and customize Java applications in the area of Geographic Information Science (GIS) which covers systems designed to capture, store, manipulate, analyze, manage, and present all types of geographical data [5].

Some of the core functionality that this API provides the programmer with is the possibility of displaying and manipulating maps (based on geographical data) and the ability to perform queries on its spatial information [4].

MapObjects also lets you merge easily two java-based Graphical User Interface (GUI) frameworks, AWT (Abstract Windowing Toolkit) and Swing. The use of these two powerful frameworks allows the developer to customize, to the developer's needs, the GUI elements provided by the MapObjects API and create new ones.

The fact that the MapObjects library was written in Java makes it the perfect companion to the programming language chosen for this project.

## 2.3 Web Technologies (HTML, CSS, JavaScript)

HTML is the main markup language for displaying web pages and other information that can be displayed in a web browser. CSS is a style sheet language that defines the appearance and layout of text and other material that is part of documents written in HTML [6].

JavaScript is a prototype-based scripting language that is dynamic, weakly typed and has first-class functions. It is primarily used in the form of client-side script language in order to create enhanced user interfaces and dynamic websites [7].

These three languages were used in the creation of the web pages that are an important part of this user application.

HTML, CSS and JavaScript are open standards and interpreted, to a certain degree, in most of today's web browsers.

## 2.4 NETBEANS (IDE)

This tool was chosen as the Integrated Development Environment to create this application because it provides a simple to use but yet powerful editor for the Java Platform. It is available for free, and it is included with the Java SE download on Oracle's web page [8].

# CHAPTER 3

# SOFTWARE REQUIREMENTS

Agile development was the process in which the development of this application, in a much smaller scale, was based on. It is defined as an iterative and incremental (evolutionary) approach to software development which is performed in a highly collaborative manner by self-organizing teams within an effective governance framework with “just enough” ceremony that produces high quality solutions in a cost effective and timely manner which meets the changing needs of its stakeholders [9].

One of the methodologies suggested by the Agile process is Extreme Programming (XP). This was the method adopted for this project. Extreme Programming is a method that stresses customer satisfaction. Instead of delivering everything you could possibly want on some date far in the future this process delivers the software you need as you need it. Extreme Programming empowers developers to confidently respond to changing customer requirements, even late in the life cycle [10]. This methodology promotes frequent releases or prototypes in short development cycles, constant code review and unit testing of all the code.

One of the techniques suggested, in Extreme Programming, for the recollection of the requirements for an application is the creation of User Stories. These stories are written by the customers as things that the system needs to do for them. They are similar to usage scenarios, except that they are not limited to describing a user interface. They are in the format of about three sentences of text written by the customer in their terminology without techno-syntax [11]. User stories also drive the creation of acceptance tests or criteria to verify that a certain feature has been correctly implemented.

Developers estimate how long the stories might take to implement. Each story will get a 1, 2 or 3 week estimate in "ideal development time" [11].

The gathering of user stories for the development of this project was based on interviews and conversations with Dr. Paula De Vos, professor of Mexican History at San Diego State University, Maricruz Alzás Almagro professor of Mexican History and

Geography at Colegio Cadi, Tijuana B.C., and Dr. Carl Eckberg, professor of Computer Science at SDSU and my advisor for this thesis.

The format in which the collected user stories are presented below is loosely based in the template found here [12].

The user stories are also presented in different groups. This grouping was based in the classification given in the Software Requirements Specification defined by the IEEE Std 830-1998 [13].

## 3.1 ARCHITECTURAL REQUIREMENTS

For the architectural requirements of this project see Table 3.1.

**Table 3.1. Architectural Requirement: Platform Independence**

| **Story Narrative** | **Platform Independence** | ***Time Estimate*** | **1 week** |
|---|---|---|---|
| **As a** | User | ***Priority*** | High |
| **I want** | I want to be able to use this application in any computer | | |
| **Acceptance Criteria** | All the users of this application (students and teachers) will be able to use it no matter the system they have access to | | |

## 3.2 FUNCTIONAL REQUIREMENTS

For the functional requirements of this project see Table 3.2, Table 3.3, Table 3.4, Table 3.5, Table 3.6, Table 3.7, Table 3.8., Table 3.9, and Table 3.10.

## 3.3 NON-FUNCTIONAL REQUIREMENTS

For the non-functional requirements of this project see Table 3.11.

## 3.4 USABILITY

For the usability requirements of this project see Table 3.12, Table 3.13, Table 3.14, Table 3.15, and Table 3.16.

**Table 3.2. Functional Requirement: Mexico's Mountain Peaks**

| **Story Narrative** | **Mexico's Mountain Peaks** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to be able to use this application to view the main mountain peaks in Mexico's map. | | |
| **Acceptance Criteria** | Be able to locate the main Mexico's peaks on a map and be able to view information about them. | | |

**Table 3.3. Functional Requirement: Mexico's Mountain Ranges**

| **Story Narrative** | **Mexico's Mountain Ranges** | ***Time Estimate*** | **3 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to be able to use this application to view the main mountain ranges in Mexico's map | | |
| **Acceptance Criteria** | Be able to locate the main Mexico's mountain ranges on a map and be able to view information about them | | |

**Table 3.4. Functional Requirement: Mexico's Rivers**

| **Story Narrative** | **Mexico's Rivers** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to be able to use this application to view the main rivers in Mexico's map. | | |
| **Acceptance Criteria** | Be able to locate the main Mexico's rivers on a map and be able to view information about them | | |

**Table 3.5. Functional Requirement: Mexico's Lakes**

| **Story Narrative** | **Mexico's Lakes** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to be able to use this application to view the main lakes in Mexico's map | | |
| **Acceptance Criteria** | Be able to locate the main Mexico's lakes on a map and be able to view information about them | | |

**Table 3.6. Functional Requirement: Mesoamerica Timeline**

| **Story Narrative** | **Mesoamerica Timeline** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to be able to view a timeline of Mesoamerica's main civilizations | | |
| **Acceptance Criteria** | Be able to display a timeline that includes information about all the archeological sites founded during Mesoamerica's apogee | | |

**Table 3.7. Functional Requirement: Mesoamerican Sites**

| **Story Narrative** | **Mesoamerican Sites** | ***Time Estimate*** | **3 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to be able to use this application to view the location of archeological sites founded over Mesoamerica's different periods: Pre-Classic, Classic and Post-Classic | | |
| **Acceptance Criteria** | Be able to locate Mesoamerica's most important archeological sites on a map of Mexico-Central America given a specific period of time | | |

**Table 3.8. Functional Requirement: Mesoamerica Region**

| **Story Narrative** | **Mesoamerica Region** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to be able to use this application to view a map that shows the area covered by the region known as Mesoamerica | | |
| **Acceptance Criteria** | Be able to display a map that includes both Mexico and Central America and mark the region covered by Mesoamerican cultures | | |

**Table 3.9. Functional Requirement: Mesoamerican Civilizations**

| **Story Narrative** | **Mesoamerican Civilizations** | ***Time Estimate*** | **3 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to be able to use this application to view the main archeological sites founded by each main Mesoamerican civilization (Olmec, Maya, Zapotec, Teotihuacana, Totonaca, Mixtec, Purepecha, Chichimeca, Toltec, Aztec) | | |
| **Acceptance Criteria** | Be able to display a map for each civilization that displays the location of each main site and marks the area (or Empire) covered by each culture | | |

**Table 3.10. Functional Requirement: Quizzes and Games**

| **Story Narrative** | **Quizzes and Games** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to be able to practice what they have learned in class by taking quizzes. If possible, make it more fun by including some games | | |
| **Acceptance Criteria** | Be able to provide some quizzes and games for students. And provide a way to grade them automatically once they are completed | | |

**Table 3.11. Non-Functional Requirement: Localization**

| **Story Narrative** | **Localization** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | User | ***Priority*** | High |
| **I want** | The application to be available in English and Spanish. | | |
| **Acceptance Criteria** | This application will be localized in the languages listed above. The desired language will be selected when the application first runs. The selected language can also be changed when the application is running using a menu item or the appropriate toolbar button. | | |

**Table 3.12. Usability Requirement: Information Display**

| **Story Narrative** | **Information Display** | ***Time Estimate*** | **3 week** |
|---|---|---|---|
| **As a** | Teacher | ***Priority*** | High |
| **I want** | I want my students to have access to more information on the material covered in class | | |
| **Acceptance Criteria** | Display the required information in a user-friendly manner using Java GUI components and HTML web pages that include images and some audio files | | |

**Table 3.13. Usability Requirement: ZoomPan Toolbar**

| **Story Narrative** | **ZoomPan Toolbar** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | User | ***Priority*** | High |
| **I want** | I want to be provided with the ability to Zoom in, Zoom out, Pan and Identify all the features that are part of each map displayed | | |
| **Acceptance Criteria** | Successfully be able to perform all the previously listed functions on all the maps displayed by the application | | |

**Table 3.14. Usability Requirement: SelectionToolbar**

| **Story Narrative** | **Selection Toolbar** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | User | ***Priority*** | High |
| **I want** | I want to be provided with the ability to ask the system for the location of a specific feature | | |
| **Acceptance Criteria** | Provide the user with tools to query the system on certain spatial information, select and highlight specific features on a map. | | |

**Table 3.15. Usability Requirement: Help Tools**

| **Story Narrative** | **Help Tools** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | User | ***Priority*** | High |
| **I want** | I want to have access to some sort of manual in order to figure out how to use the application | | |
| **Acceptance Criteria** | Provide the user of the application with a User Manual and a help tool, easily accessible from the menu bar. The help tool will provide a way to find out how to use the toolbar buttons | | |

**Table 3.16. Usability Requirement: Modify Map's Appearance**

| **Story Narrative** | **Modify Map's Appearance** | ***Time Estimate*** | **2 week** |
|---|---|---|---|
| **As a** | User | ***Priority*** | High |
| **I want** | I want to be provided with the ability to modify the appearance of the displayed maps (colors, labels, etc) | | |
| **Acceptance Criteria** | Provide the user with an appearance editor where the color of the map, features and legends can be updated. Also provide the user with menu options to add or delete layers from a map. | | |

# CHAPTER 4

# DATA COLLECTION AND ANALYSIS

For the implementation of this project a great amount of data was required. The sources for all the data collected for the implementation of this application are listed and briefly discussed in the next few sections.

A three step process was generally followed in the creation of all the map layers.

- Collection of geographical coordinates for the physical features of all the maps presented.
- CSV (Comma-Separated Values) files were generated using the previous collected coordinates. CSV files store tabular data (numbers and data) in plain text format. They consist of any number of records, separated by line breaks of some kind; each record consists of fields, separated by some character or string, most commonly a literal comma or tab [14]. See Figure 4.1.

  Similar CSV files, like the one presented in Figure 4.1 were prepared for all the map layers presented as part of this application.
- Implementation of Java code to read the CSV files and generate the appropriate type of layer (point, polyline or polygon) in SHP format (shapefile) in order to be displayed using the Map Objects API. The shapefile format is a geospatial vector data format for GIS software that was developed by ESRI, it is currently an open specification [15].

For the following point layers all the GPS (Global Positioning System) coordinates were obtained through two different tools:

- WikiProject Geographical Coordinates [16], a tool that is used by cartographers around the world to obtain latitude and longitude coordinates of a particular physical world feature [17].
- GeoHack, a modified version of map sources from Egil Kvaleberg's GIS extension. This tool functions as a web service that provides links to various mapping services, given specific geographical coordinates, in order to locate them with different applications like Google Earth, Google Maps, Nokia Maps, MapQuest, etc. [18].

These are the point layers that were constructed using the two previously mentioned tools:

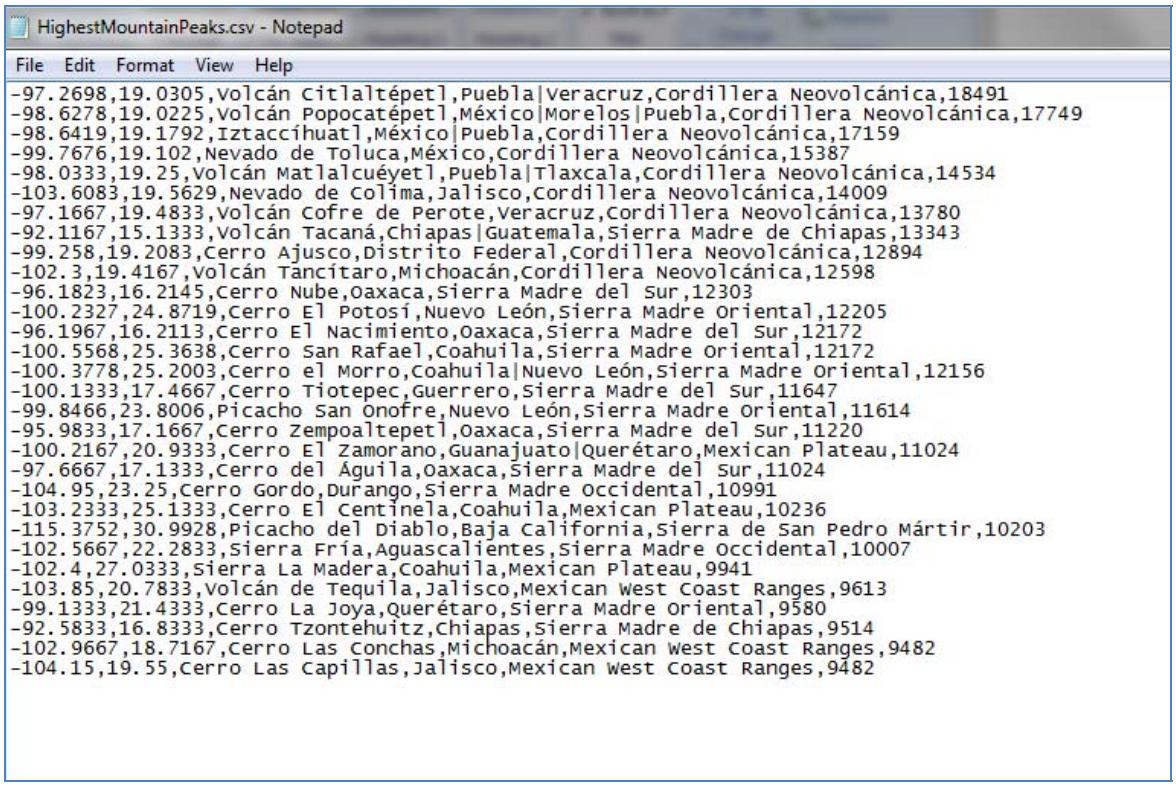

HighestMountainPeaks.csv - Notepad
File Edit Format View Help
-97.2698,19.0305,Volcán Citlaltépetl,Puebla|Veracruz,Cordillera Neovolcánica,18491
-98.6278,19.0225,Volcán Popocatépetl,México|Morelos|Puebla,Cordillera Neovolcánica,17749
-98.6419,19.1792,Iztaccíhuatl,México|Puebla,Cordillera Neovolcánica,17159
-99.7676,19.102,Nevado de Toluca,México,Cordillera Neovolcánica,15387
-98.0333,19.25,Volcán Matlalcuéyetl,Puebla|Tlaxcala,Cordillera Neovolcánica,14534
-103.6083,19.5629,Nevado de Colima,Jalisco,Cordillera Neovolcánica,14009
-97.1667,19.4833,Volcán Cofre de Perote,Veracruz,Cordillera Neovolcánica,13780
-92.1167,15.1333,Volcán Tacaná,Chiapas|Guatemala,Sierra Madre de Chiapas,13343
-99.258,19.2083,Cerro Ajusco,Distrito Federal,Cordillera Neovolcánica,12894
-102.3,19.4167,Volcán Tancítaro,Michoacán,Cordillera Neovolcánica,12598
-96.1823,16.2145,Cerro Nube,Oaxaca,Sierra Madre del Sur,12303
-100.2327,24.8719,Cerro El Potosí,Nuevo León,Sierra Madre Oriental,12205
-96.1967,16.2113,Cerro El Nacimiento,Oaxaca,Sierra Madre del Sur,12172
-100.5568,25.3638,Cerro San Rafael,Coahuila,Sierra Madre Oriental,12172
-100.3778,25.2003,Cerro el Morro,Coahuila|Nuevo León,Sierra Madre Oriental,12156
-100.1333,17.4667,Cerro Tiotepec,Guerrero,Sierra Madre del Sur,11647
-99.8466,23.8006,Picacho San Onofre,Nuevo León,Sierra Madre Oriental,11614
-95.9833,17.1667,Cerro Zempoaltepetl,Oaxaca,Sierra Madre del Sur,11220
-100.2167,20.9333,Cerro El Zamorano,Guanajuato|Querétaro,Mexican Plateau,11024
-97.6667,17.1333,Cerro del Águila,Oaxaca,Sierra Madre del Sur,11024
-104.95,23.25,Cerro Gordo,Durango,Sierra Madre Occidental,10991
-103.2333,25.1333,Cerro El Centinela,Coahuila,Mexican Plateau,10236
-115.3752,30.9928,Picacho del Diablo,Baja California,Sierra de San Pedro Mártir,10203
-102.5667,22.2833,Sierra Fría,Aguascalientes,Sierra Madre Occidental,10007
-102.4,27.0333,Sierra La Madera,Coahuila,Mexican Plateau,9941
-103.85,20.7833,Volcán de Tequila,Jalisco,Mexican West Coast Ranges,9613
-99.1333,21.4333,Cerro La Joya,Querétaro,Sierra Madre Oriental,9580
-92.5833,16.8333,Cerro Tzontehuitz,Chiapas,Sierra Madre de Chiapas,9514
-102.9667,18.7167,Cerro Las Conchas,Michoacán,Mexican West Coast Ranges,9482
-104.15,19.55,Cerro Las Capillas,Jalisco,Mexican West Coast Ranges,9482

**Figure 4.1. Highest mountain peaks CSV file. The first and second fields are the longitude and latitude respectively. The third and fourth are the name of the peak and the states in Mexico it's in and the last field is the elevation of the peak in ft (for the Spanish version of the application this value was converted to meters).**

- **Mexico's Highest Mountain Peaks:** The 30 highest mountain peaks were obtained from the list of highest peaks in Mexico found in this non-commercial database [19]. For this point layer a map of the states of Mexico was used as a base layer.
- **Mesoamerica's Pre-Classic, Classic and Post-Classic Sites:** The main sites for each period in Mesoamerica's history were obtained through research in texts recommended by Dr. De Vos and Professor Alzás [20-26]. For this point layer a map of the Mexico-Central America region was used as a base layer.
- **Mesoamerican civilization's sites (Olmec, Mayan, Aztec, Zapotec, Teotihuacana, Mixtec, Toltec, Totonaca, Chichimeca, Purépecha):** The main sites for each Mesoamerican civilization were obtained through research in texts recommended by Dr. De Vos and Professor Alzás [20-26]. For this point layers a map of the Mexico-Central America region was used as a base layer.

  The polyline and polygon layers listed below were created using different sources.

- **Mexico's states:** The data used to create the states layer was obtained from the ArcGIS application, a Geographical Information System (GIS) developed by ESRI [27] that provides, as part of its sample data, information on the states of Mexico with

coastlines, international boundaries, and state boundaries. This layer was used as a base for other map layers presented in this application.

- **Mexico-Central America borders:** The data used to create this layer was obtained from the U.S. Geological Survey website. This website provides a world vector shoreline of the Mexico and Central America region [28]. This layer was used as a base for other map layers presented in this application.

- **Mexico's Main Mountain Ranges:** The data obtained to create this layer was obtained from Peakbagger, a non-commercial web site that supports a large dynamic database of peaks, ranges and climbers [19].

  This large mountain ranges database is based on a hierarchical classification that divides the entire land surface of the earth into ranges and sub ranges. The full classification's rules can be found here [29].

  The data for the mountain ranges' borders presented on this website using Google Maps' web service, was used to draw the six main mountain ranges (Sierra Madre Occidental, Sierra Madre Oriental, Mexican Plateau, Cordillera Neovolcánica, West Coast Ranges and Sierra Madre del Sur) on a map of Mexico.

  For this layer a map of the states of Mexico was used as a base layer.

- **Mexico's Main Rivers:** The data used to create the rivers layer was obtained from the ArcGIS application, a Geographical Information System (GIS) developed by ESRI [27] that provides, as part of its sample data, information on the location of the rivers on Mexico's map.

  For this layer a map of the states of Mexico was used as a base layer.

- **Mexico's Main Lakes:** The data used to create the lakes layer was obtained from DIVA-GIS, a website that provides free geographic data from any country in the world. The development of DIVA-GIS has been supported by global organizations like Biodiversity International and the University of California Berkeley, among others [30].

  The data obtained from [30] to create the lakes layer, contained some unnecessary information, for this particular project. It included data about some water areas that referred to artificial lakes, dams or they were just no relevant to the Geography Program of Studies described by professor Alzás. For this reason, an algorithm needed to be implemented to extract the desired data and create the appropriate layer from this selection. The process followed to achieve this will be discussed in the Implementation chapter of this document. For this layer a map of the states of Mexico was used as a base layer.

- ***Mesoamerica's Region:*** Since no accurate GIS data is available for the Pre-Hispanic Mesoamerica's borders, the Mesoamerica Region layer was created as an approximation of what that area used to cover considering the location of the archeological sites founded by the ten major cultures that developed in the region. Data from the Foundation for the Advancement of Mesoamerican Studies, Inc

(FAMSI) [31] and visual maps provided here [22-26] were used for the creation of this layer. See Figure 4.2 [32].

For this layer a map of the Mexico-Central America region was used as a base layer.

- ***Mesoamerica's civilizations borders (Olmec, Maya, Zapotec, Aztec, Teotihuacana, Mixtec, Toltec, Totonaca, Chichimeca, Purépecha):*** Since not very accurate GIS data is available for Pre-Hispanic Mesoamerica's civilizations borders, each culture's area layer was created as an approximation of what it used to cover considering the location of the archeological sites founded by a given civilization. Data from the Foundation for the Advancement of Mesoamerican Studies, Inc (FAMSI) [31] and visual maps provided here [22-26] were used for the creation of these layers.

For these layers a map of the Mexico-Central America region was used as a base layer.

**Figure 4.2. Mesoamerica's pre-Hispanic borders. The borders of the 3 most important civilizations (Olmec, Mayan, Aztec) are also seen in this figure. Source: A. LAUDUN, *The Maya astronaut: Pakal the great.* Wordpress, http://alaudun77.wordpress.com/author/alaudun/, accessed June 2012, 2011.**

# CHAPTER 5

# SOFTWARE IMPLEMENTATION

In this chapter the process followed for the implementation of this application will be discussed. Several screen shots will be presented to provide a visual guide to the reader.

## 5.1 LOCALIZATION

The localization of this application was introduced as early as possible in the implementation process.

When the user first runs the application, a dialog (see Figure 5.1) will be displayed. This way the user will select the language of preference. From this point on, all the messages displayed by the program will be localized in the previously selected language.

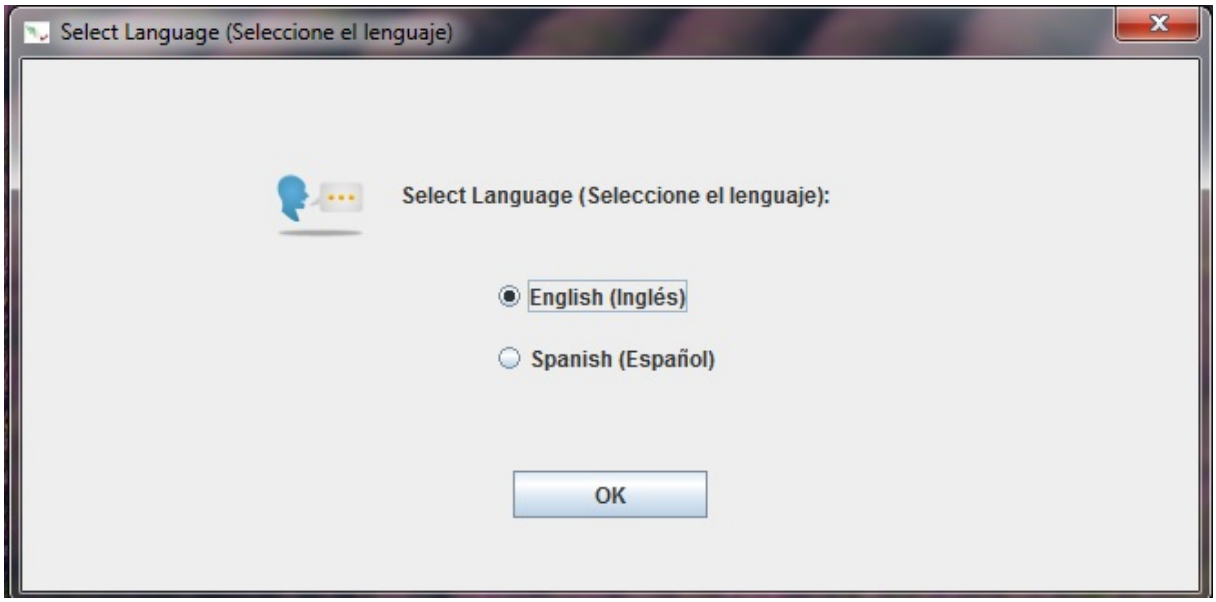



**Figure 5.1. Select Language dialog.**

The localization for this application was implemented using the java library **ResourceBundle.** Two property files (files that contain each localized message as a pair of strings, key-value, per line), one with the localized messages in English and the other one with the messages in Spanish (see Figure 5.2) were created to work with this library.

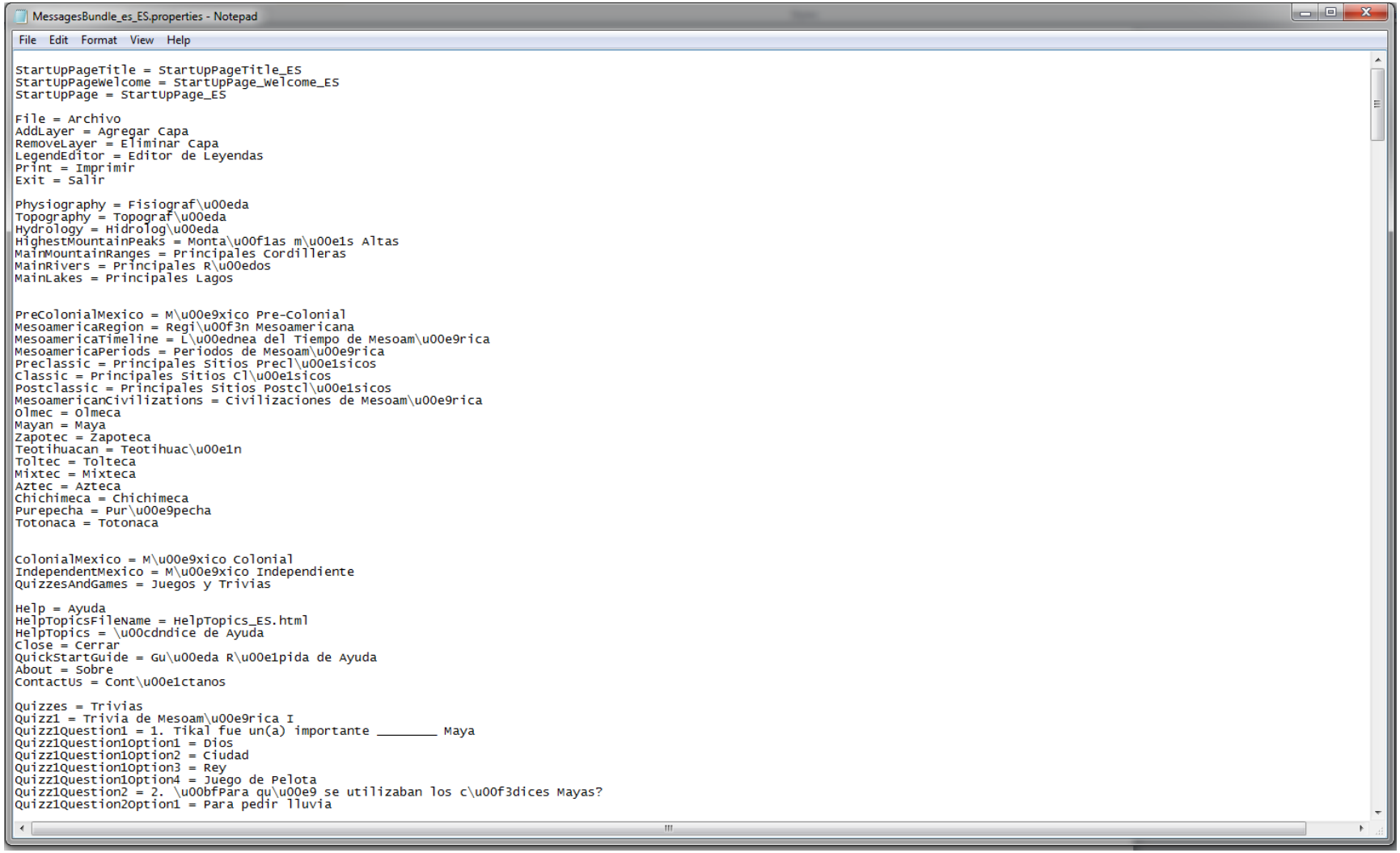

MessagesBundle_es_ES.properties - Notepad
File Edit Format View Help
StartUpPageTitle = StartUpPageTitle_ES
StartUpPageWelcome = StartUpPage_Welcome_ES
StartUpPage = StartUpPage_ES
File = Archivo
AddLayer = Agregar Capa
RemoveLayer = Eliminar Capa
LegendEditor = Editor de Leyendas
Print = Imprimir
Exit = Salir
Physiography = Fisiograf\u00eda
Topography = Topograf\u00eda
Hydrology = Hidrolog\u00eda
HighestMountainPeaks = Monta\u00f1as m\u00e1s Altas
MainMountainRanges = Principales Cordilleras
MainRivers = Principales R\u00edos
MainLakes = Principales Lagos
PreColonialMexico = M\u00e9xico Pre-Colonial
MesoamericaRegion = Regi\u00f3n Mesoamericana
MesoamericaTimeline = L\u00ednea del Tiempo de Mesoam\u00e9rica
MesoamericaPeriods = Periodos de Mesoam\u00e9rica
Preclassic = Principales Sitios Precl\u00e1sicos
Classic = Principales Sitios Cl\u00e1sicos
Postclassic = Principales Sitios Postcl\u00e1sicos
MesoamericanCivilizations = Civilizaciones de Mesoam\u00e9rica
Olmec = Olmeca
Mayan = Maya
Zapotec = Zapoteca
Teotihuacan = Teotihuac\u00e1n
Toltec = Tolteca
Mixtec = Mixteca
Aztec = Azteca
Chichimeca = Chichimeca
Purepecha = Pur\u00e9pecha
Totonaca = Totonaca
ColonialMexico = M\u00e9xico Colonial
IndependentMexico = M\u00e9xico Independiente
QuizzesAndGames = Juegos y Trivias
Help = Ayuda
HelpTopicsFileName = HelpTopics_ES.html
HelpTopics = \u00cdndice de Ayuda
Close = Cerrar
QuickStartGuide = Gu\u00eda R\u00e1pida de Ayuda
About = Sobre
ContactUs = Cont\u00e1ctanos
Quizzes = Trivias
Quizz1 = Trivia de Mesoam\u00e9rica I
Quizz1Question1 = 1. Tikal fue un(a) importante _____ Maya
Quizz1Question1Option1 = Dios
Quizz1Question1Option2 = Ciudad
Quizz1Question1Option3 = Rey
Quizz1Question1Option4 = Juego de Pelota
Quizz1Question2 = 2. \u00bfPara qu\u00e9 se utilizaban los c\u00f3dices Mayas?
Quizz1Question2Option1 = Para pedir lluvia

**Figure 5.2. Localization property file. Contains the application's messages in Spanish.**

## 5.2 START PAGE

After the user selects the language of preference, the “Start Page” for the application is displayed. The purpose of this page is to provide the user with a home page were he/she will have access to a “Quick Start Guide” on how to use the program, and where a list of all the main menus will be shown (see Figure 5.3).

## 5.3 APPLICATION’S MAIN WINDOW

The application’s main window is divided in several parts indicated in Figure 5.4.

Most of the parts indicated in Figure 5.4 are very intuitive, and further explained in the user manual. In this document I’m just going to add a little more information on the “Table of Contents” and the “Status Bar”.

The “Table of Contents” is located to the left of the map area and it contains a list of all the map’s layers currently displayed, it also serves as the legend’s definition that identifies each feature on the map. The “Status Bar” displays the coordinate in the map to which the cursor currently points at, and it is dynamically updated as the mouse’s pointer moves.

## 5.4 CREATION OF THE MAP LAYERS

In order to present to the user of this application all the maps the way they are, two or more layers needed to be created for each map and rendered in a user-friendly way.

### 5.4.1 Point Layers

For the creation of the point layers, the method described in the chapter “Data Collection and Analysis” was followed. Part of the code used to parse the CSV files, like the one presented in Figure 4.1., can be seen in Figure 5.5.

The code snippet seen in Figure 5.5 was modified depending on the point layer that was being created, in order to process the appropriate data for it. In this case, the CSV file being processed was the one for the Highest Mountain Peaks in Mexico, so the data to be parsed was the GPS coordinate (longitude, latitude), the peak’s name, the states where the peak is in, the mountain range to which it belongs and the peak’s elevation.

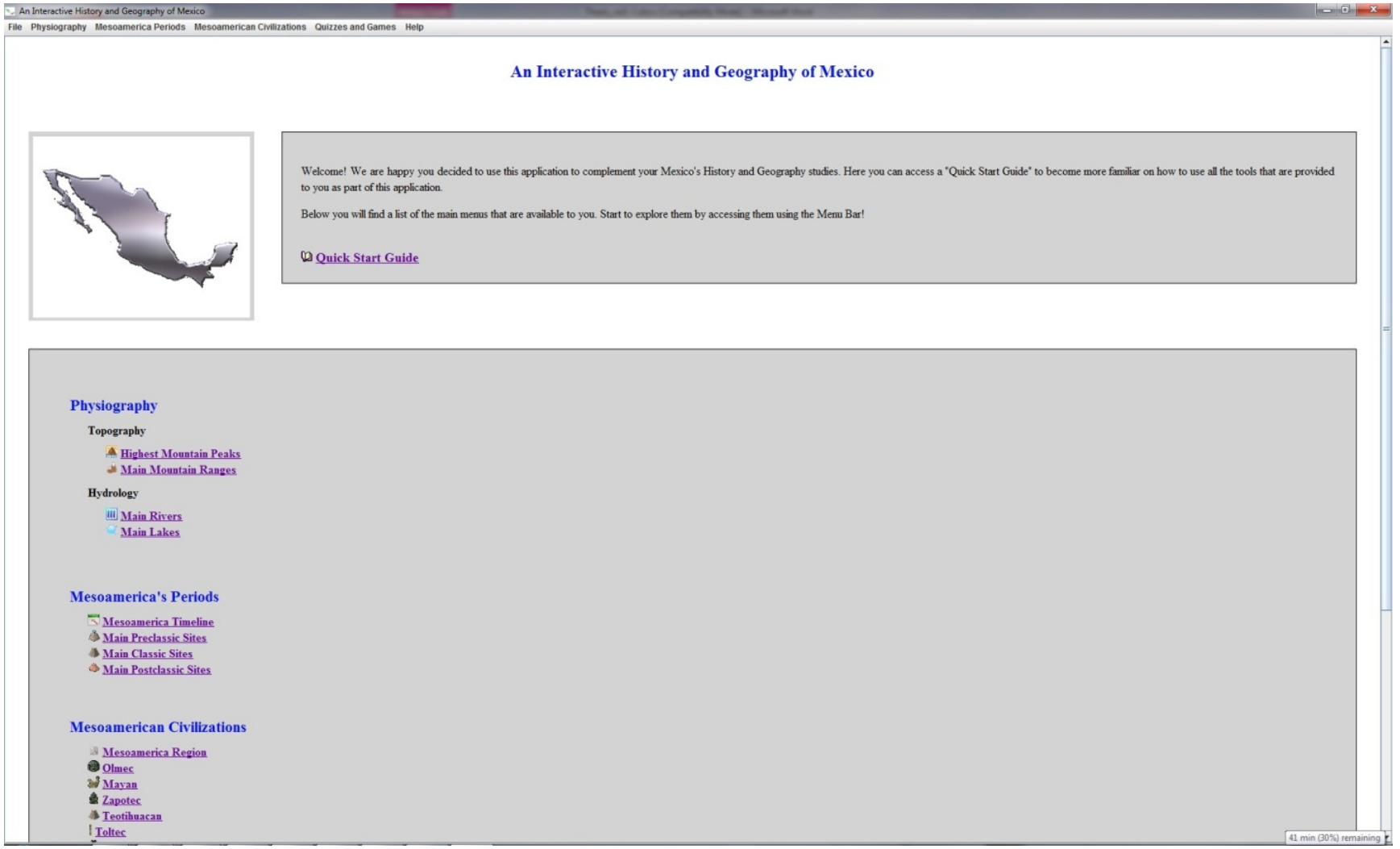

An Interactive History and Geography of Mexico
File Physiography Mesoamerica Periods Mesoamerican Civilizations Quizzes and Games Help
An Interactive History and Geography of Mexico
Welcome! We are happy you decided to use this application to complement your Mexico's History and Geography studies. Here you can access a "Quick Start Guide" to become more familiar on how to use all the tools that are provided to you as part of this application.
Below you will find a list of the main menus that are available to you. Start to explore them by accessing them using the Menu Bar!
Quick Start Guide
Physiography
Topography
Highest Mountain Peaks
Main Mountain Ranges
Hydrology
Main Rivers
Main Lakes
Mesoamerica's Periods
Mesoamerica Timeline
Main Preclassic Sites
Main Classic Sites
Main Postclassic Sites
Mesoamerican Civilizations
Mesoamerica Region
Olmec
Mayan
Zapotec
Teotihuacan
Toltec
41 min (30%) remaining

**Figure 5.3. Application's start page.**

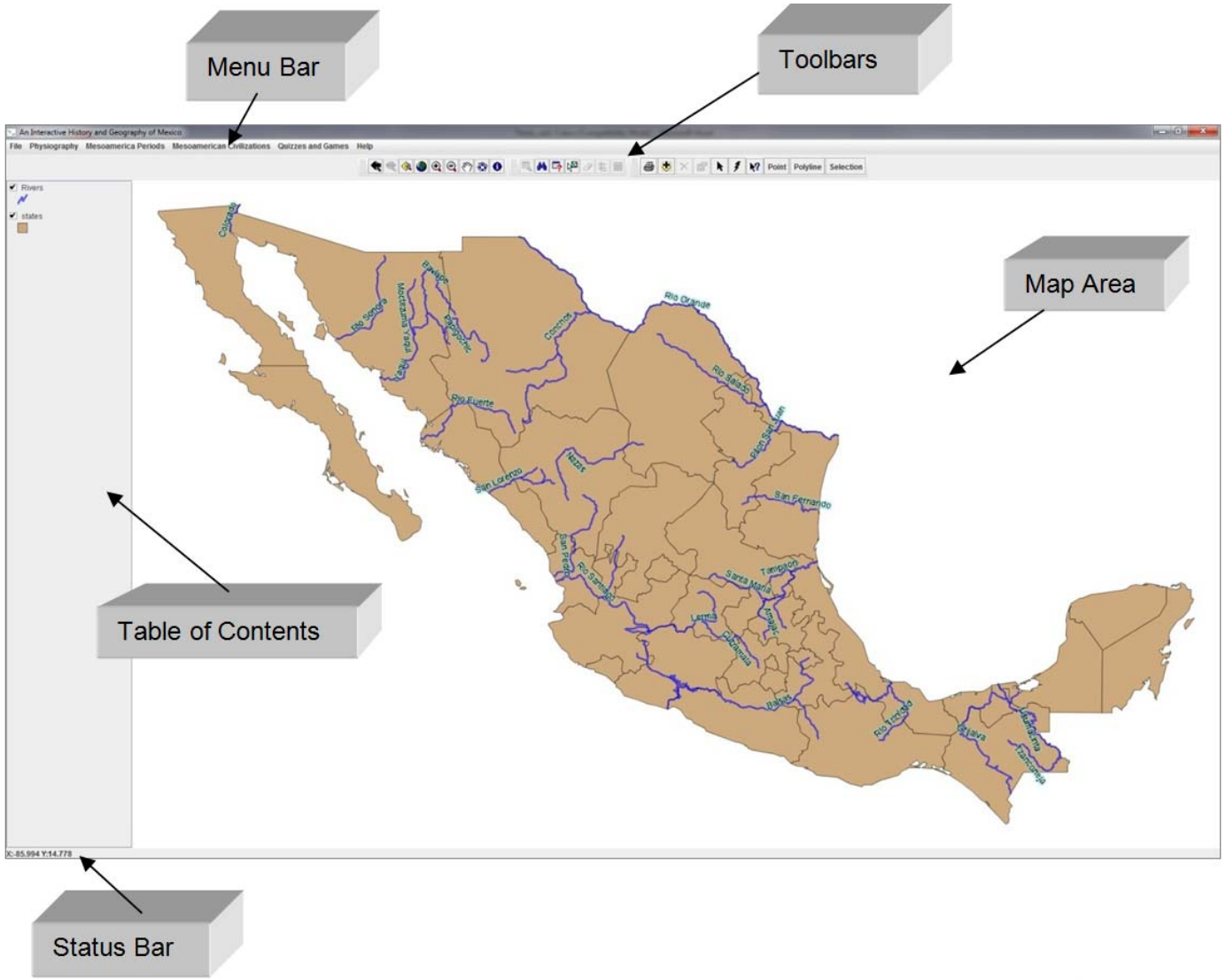



**Figure 5.4 Application's main window.**

```
java.io.File inputFile = fileChooser.getSelectedFile();
java.io.FileReader fileReader = new java.io.FileReader(inputFile);
java.io.BufferedReader bufferedReader = new java.io.BufferedReader(fileReader);
String inputString;
double longitude, latitude;
int pointIndex=0;

while((inputString = bufferedReader.readLine())!= null){
  java.util.StringTokenizer st = new java.util.StringTokenizer(inputString,",");
  longitude = Double.parseDouble(st.nextToken());
  latitude = Double.parseDouble(st.nextToken());
  peakNames.add(st.nextToken());
  states.add(st.nextToken());
  ranges.add(st.nextToken());
  elevations.add(st.nextToken());
  basePointsArray.insertPoint(pointIndex++, new com.esri.mo2.cs.geom.Point(longitude,latitude));
}
```

**Figure 5.5 Code snippet to process CSV files for point layers.**

After the data was parsed from each CSV file, the appropriate database fields were created and its type defined using the Map Objects API (this code is not presented as part of this document). With the data parsed and the database fields defined, the Feature Layer was created and the display properties rendered (color, graphics, etc) in the way they are presented in the application. The point layer(s) was then added to the appropriate base layer. In the case of the Highest Mountain Peaks layer, the base layer was the states of Mexico, as seen in Figure 5.6.

### 5.4.2 Polyline and Polygon Layers

For the creation of the polyline and polygon layers, the method described in the chapter “Data Collection and Analysis" was followed.

The creation of these types of layers was more complex than the creation of point layers, especially when accurate GIS data was not available, like it was the case for the Pre-Hispanic Mesoamerica’s borders, the Mesoamerican Civilizations borders and the Mountain Ranges.

For the previous reason, code needed to be implemented to be able to draw on a map, register the GPS coordinates and save them to a CSV file to be parsed later into a polyline layer. A snippet of the code used for this can be seen in Figure 5.7.

Once the CSV file for the polyline layer was generated, the file was parsed. A snippet of the code used to parse the CSV files for polyline layers can be seen in Figure 5.8.

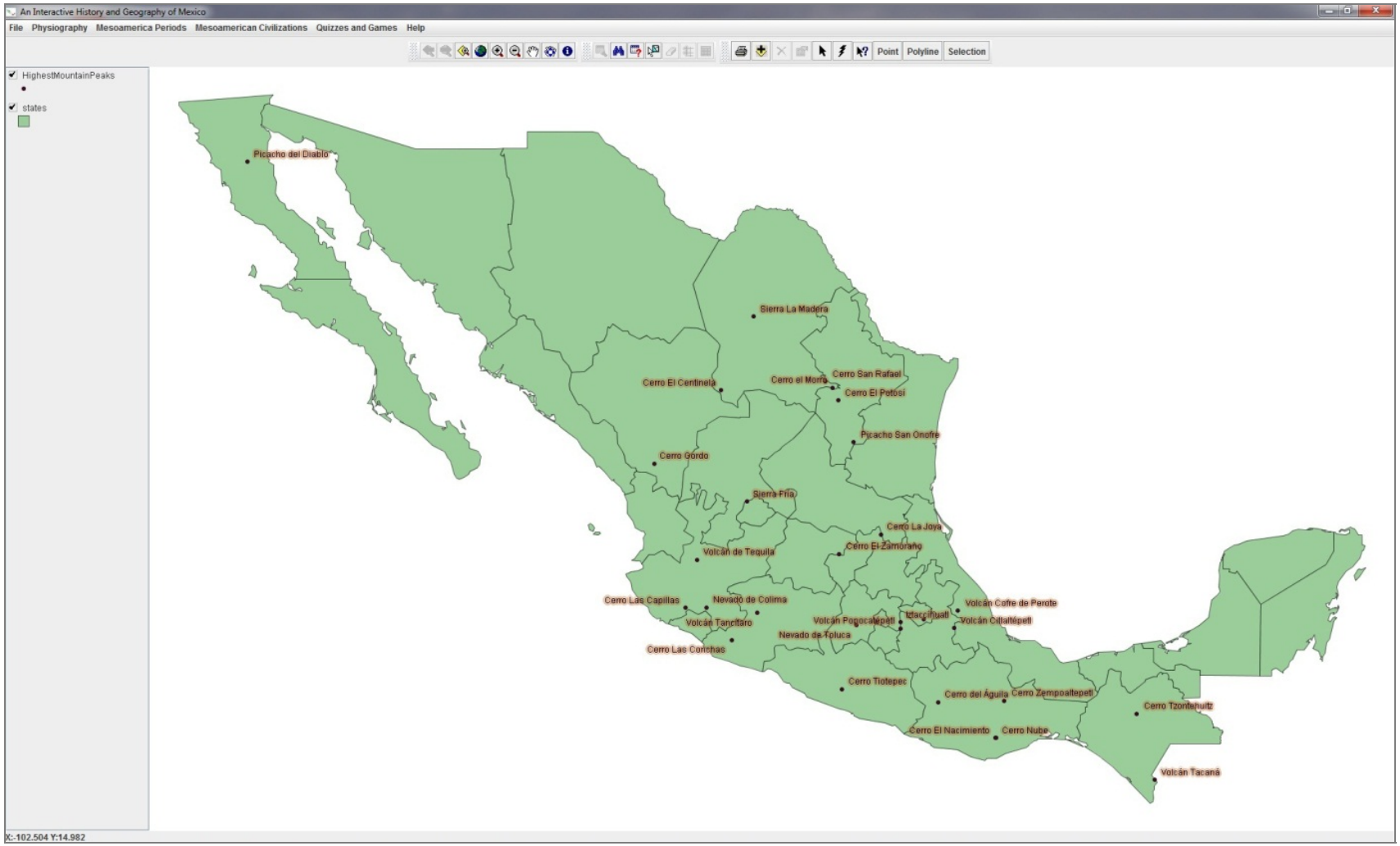



**Figure 5.6. Mexico's highest mountain peaks map. This map has two layers, a polygon base layer of Mexico's states and a point layer with the highest peaks in the country.**

```
currentMap.addMouseMotionListener(new MouseMotionAdapter() {
  @Override
  public void mouseMoved(MouseEvent mouseEvent)
  {
              com.esri.mo2.cs.geom.Point worldPoint = null;
              if(currentMap.getLayerCount() > 0)            //The Map is not empty
              {
                worldPoint = currentMap.transformPixelToWorld(mouseEvent.getX(), mouseEvent.getY());
                String coordinate = "X:" + statusBarDecimalFormat.format(worldPoint.getX()) + " " +
                "Y:" + statusBarDecimalFormat.format(worldPoint.getY());
                statusBar.setText(coordinate);
                String coordinate2 = statusBarDecimalFormat.format(worldPoint.getX()) + "," +
                                     statusBarDecimalFormat.format(worldPoint.getY());
                 try {
                      // Create file
                      FileWriter fstream = new FileWriter("out.csv",true);
                      BufferedWriter out = new BufferedWriter(fstream);
                      out.write("," + coordinate2);

                      //Close the output stream
                      out.close();
                    }

                 catch (Exception e)   {       System.err.println("Error: " + e.getMessage());      }

               }   //End if

              else  {   statusBar.setText("X:0.000 Y:0.000");  }

  } } );     //End of addMouseMotionListener
```

**Figure 5.7. Code snippet to track a series of coordinates, based on the mouse's pointer movement.**

The code snippet seen in Figure 5.8 was modified depending on the polyline layer that was being created, in order to process the appropriate data for it. In the CSV file processed with the previous code each line has all the GPS coordinates for each polyline that is part of the layer being created.

After the data was parsed from each CSV file, the appropriate database fields were created and its type defined using the Map Objects API (this code is not presented as part of this document). With the data parsed and the database fields defined, the Polyline Feature Layer was created and the display properties rendered (color, graphics, etc) in the way they are presented in this application. The polyline layer(s) was then added to the appropriate base layer. In the case of the Mesoamerica's Region map, the base layer was the Mexico-Central America layer, as seen in Figure 5.9.

```
java.io.File inputFile = fileChooser.getSelectedFile();
java.io.FileReader fileReader = new java.io.FileReader(inputFile);
java.io.BufferedReader bufferedReader = new java.io.BufferedReader(fileReader);
String inputString;
com.esri.mo2.cs.geom.BasePointsArray bpa = new com.esri.mo2.cs.geom.BasePointsArray();
double longitude, latitude;
int pointIndex=0;

while((inputString = bufferedReader.readLine())!= null)
{
        java.util.StringTokenizer st = new java.util.StringTokenizer(s,",");
        int limit = st.countTokens();

        for(int index=0; index<limit/2; index++)
        {
          longitude = Double.parseDouble(st.nextToken());
          latitude = Double.parseDouble(st.nextToken());
          bpa.insertPoint(pointIndex++, new com.esri.mo2.cs.geom.Point(longitude,latitude));
        }
        //polylinesNames.add(st.nextToken());      //Uncommented when there's text or data fields in CSV file
        //highestPoints.add(st.nextToken());
        //areas.add(st.nextToken());
        //extents.add(st.nextToken());
        polylines.add(new com.esri.mo2.cs.geom.BasePolyline(new com.esri.mo2.cs.geom.BasePath(bpa)));
        bpa = new com.esri.mo2.cs.geom.BasePointsArray();
        pointIndex=0;
}
```

**Figure 5.8 Code snippet to process CSV files for polyline layers.**

A similar process to the one described for the creation of polyline layers can be followed for the creation of polygon layers by using the appropriate Map Object API classes.

### 5.4.3 Creation of a Layer from a Selection

For the creation of Mexico's main lakes layer a special algorithm needed to be implemented to select the desired data because of the reasons explained in the "Data Collection and Analysis" chapter.

A snippet of the code used for this purpose can be seen in Figure 5.10.

The way the code, seen in Figure 5.10, works is by using the source data from the lakes layer obtained from [30] and querying its database using a form of SQL (Structured Query Language) supported by the Map Objects API. The SQL query was constructed based on input from professor Alzás, who provided the name of the lakes that she wanted to see in the final Mexico's lakes map.

With the obtained data, from querying the lake's database, the Mexico's main lakes layer was generated in shapefile format.

**Figure 5.9. Prehispanic Mesoamerica Region map**

```
com.esri.mo2.map.dpy.FeatureLayer featureLayer =
                    (com.esri.mo2.map.dpy.FeatureLayer)currentMap.getLayer("Lakes");
com.esri.mo2.file.shp.DbaseTable tableData = new com.esri.mo2.file.shp.DbaseTable(
                                                    new
                    java.io.File("C:\\ESRI\\MOJ23\\Samples\\Data\\MEXICO\\Lakes.dbf"));
com.esri.mo2.data.feat.BaseQueryFilter queryFilter = new com.esri.mo2.data.feat.BaseQueryFilter();
queryFilter.setWhereClause("NAME like '%MIRAMAR%' or NAME like '%BACALAR%' or NAME like
'%CATEMACO%'
                                    or NAME  like '%CHAPALA%' " +
                                    "or NAME like '%CUITZEO%' or NAME like '%YURIRIA%' or NAME like
                    '%PATZCUARO%'
                                    or NAME like '%SAYULA%' " +
                                    "or NAME like '%TEQUESQUITENGO%' or NAME like '%TEXCOCO%'
                                    or NAME like '%GUZMAN%' " +
                                    "or NAME like '%ZIRAHUEN%' or NAME like '%TRES PALOS%' or
                                (NAME  like  'LAGUNA SALADA'  and  HYC_DESCRI  like  'Non-
                    Perennial/Intermittent/Fluctuating') " +
                                "or NAME like '%TAMIAHUA%'");
queryFilter.setSubFields(featureLayer.getFeatureClass().getFields());
com.esri.mo2.map.dpy.FeatureLayer newLayer =
                    featureLayer.createSelectionLayer(featureLayer.select(queryFilter));
com.esri.mo2.file.shp.ShapefileWriter.writeFeatureLayer(newLayer,MEXICO_DATA_DIRECTORY_PATH,"Sel
                    ection",2);
```

**Figure 5.10 Code snippet to create the lakes layer from a selection of data.**

## 5.5 APPLICATION'S TOOLBARS

This application has three main toolbars. The Zoom/Pan Toolbar and the Selection Toolbar are the two standard ones that should be present, in some form, in most GIS applications that provide the user with an interactive map. These two toolbars are supported by the Map Objects API and can be customized, in some way, for a particular GIS application. The third toolbar was specifically created and customized for this project. In the next few sections the previously mentioned toolbars will be briefly discussed. The customized toolbar will be reviewed in more depth.

### 5.5.1 Zoom/Pan Toolbar

The Zoom/Pan Toolbar contains nine standard buttons. The functionality of every one of them is briefly described in this section.

The toolbar seen in Figure 5.11 provides the user with the ability to manipulate the current map by zooming on it and moving it in a specific direction. It also allows to identify each feature on the current map.

**Figure 5.11. Zoom/pan toolbar.**

#### 5.5.1.1 PREVIOUS EXTENT

Every time before the user modifies the scale of the map by using any of the zoom or pan tools, a view of the map with its current scale gets saved to the extent history. So when this tool button is used (see Figure 5.12), it zooms the map to the previous extent stored in the extent history (it works like an undo for maps).

**Figure 5.12. Previous extent tool button.**

#### 5.5.1.2 NEXT EXTENT

Every time before the user modifies the scale of the map by using any of the zoom or pan tools, a view of the map with its current scale gets saved to the extent history. So when this tool button is used (see Figure 5.13), it zooms to the next extent stored in the extent history (it works like a redo for maps).

**Figure 5.13. Next extent tool button.**

#### 5.5.1.3 ZOOM TO ACTIVE LAYER

This tool zooms the map to the extent of all the features that are part of the selected layer(s). This way the view of the map, after this button is pressed (see Figure 5.14), it's scaled in a way that includes all the selected layer's features and not more.

**Figure 5.14. Zoom to active layer tool button.**

#### 5.5.1.4 ZOOM TO FULL EXTENT

This tool zooms the map to the extent of all layers within the map. This means that after pressing this tool button (see Figure 5.15) we get an eagle eye view of the entire map changing the scale of it appropriately.

**Figure 5.15. Zoom to full extent tool button.**

#### 5.5.1.5 ZOOM IN

Provides a tool for clicking or dragging a rectangle on the map in order to zoom in. The scale for the current map is modified accordingly. When using this tool (see Figure 5.16), the cursor changes to a "zoom in magnifier" to indicate that the tool is active. In order to unselect the tool, the cursor tool button needs to be pressed (see section 5.5.3.5).

**Figure 5.16. Zoom in tool button.**

#### 5.5.1.6 ZOOM OUT

Provides a tool for clicking or dragging a rectangle on the map in order to zoom out. The scale for the current map is modified accordingly. When using this tool (see Figure 5.17), the cursor changes to a "zoom out magnifier" to indicate that the tool is active. In order to unselect the tool, the cursor tool button needs to be pressed (see section 5.5.3.5).

**Figure 5.17. Zoom out tool button.**

#### 5.5.1.7 PAN

This button provides a tool for dragging the map to a new location without altering the map's scale. When using this tool (see Figure 5.18), the cursor changes to a hand shape to indicate that the tool is active. In order to unselect the tool, the arrow (cursor) tool button needs to be pressed (see section 5.5.3.5).

**Figure 5.18. Pan tool button.**

#### 5.5.1.8 PAN IN ONE DIRECTION

Pans the map in one of four directions: north, south, east, or west. When pressing this tool button (see Figure 5.19), the drop down list, seen in Figure 5.20, is displayed.

**Figure 5.19. Pan in one direction tool button.**

**Figure 5.20. Pan in one direction's drop down list.**

The list includes the options for panning the map north, south, east or west. The percentage to pan is based on the current map's extent and it is applied toward the clicked panbar direction. This percentage can be programmatically modified through the public method **setPanPace(double percentage)** of the **PanPanel** class.

#### 5.5.1.9 IDENTIFY

Performs and identify function on the features that are part of the currently selected layer. When using this tool (see Figure 5.21), the cursor changes to a smaller pointer that has an information sign on top, to indicate that the tool is active. In order to unselect the tool, the arrow (cursor) tool button needs to be pressed (see section 5.5.3.5).

**Figure 5.21. Identify tool button.**

In the case of the highest mountain peaks in Mexico map, if you use the "Identify" tool button and select the peak "Sierra La Madera," by clicking on it, this feature will be highlighted and after that, a table displaying all the peak's properties will be displayed to the user. This table can be seen in Figure 5.22.

### 5.5.2 Selection Toolbar

The Selection Toolbar contains seven standard buttons. The functionality of six of them will be briefly described in this section.

The Selection toolbar, seen in Figure 5.23, provides the user with the ability to query on spatial data associated with the current map.

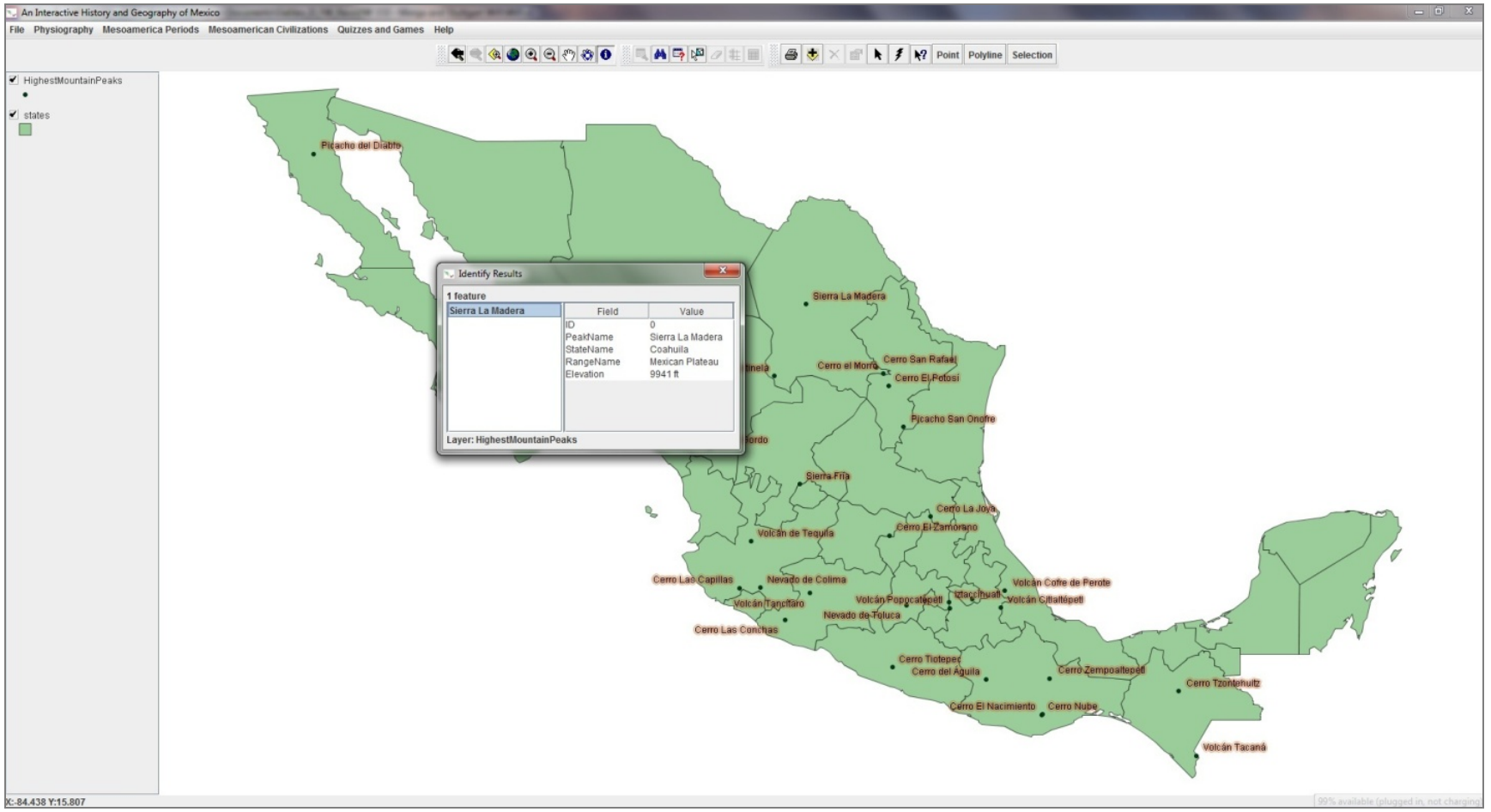



**Figure 5.22. Identify tool's table. Table displayed when using identify tool on a map's feature.**

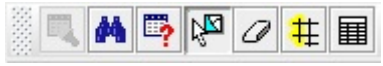


**Figure 5.23. Selection toolbar.**

#### 5.5.2.1 FIND

This tool (see Figure 5.24) opens a dialog to locate features on the current map whose attributes contain an end-user provided string. It doesn't have to be an exact match. As long as the provided string is contained in any database field of any feature that is part of the selected layer, it will return the first match and the feature will be highlighted on the map. Figure 5.25 illustrates the "Find" dialog.

**Figure 5.24. Find tool button.**

#### 5.5.2.2 QUERY BUILDER

This tool (see Figure 5.26) opens a dialog for locating features based on a query that an end-user constructs using a subset of SQL logical and comparison operators provided in the same dialog. After the statement gets executed the result records are displayed in a table and the result features are highlighted on the map. Figure 5.27 shows what the "Query Builder" dialog looks like.

#### 5.5.2.3 SELECT FEATURES

This tool (see Figure 5.28) provides a way for selecting features by rubberbanding a shape on the map. When the user presses the tool button, the drop down list seen in Figure 5.29 is displayed.

The list (seen in Figure 5.29) includes the options for using a rectangle, circle, line or polygon shape to draw on the map in order to select the desired features. When the user releases the left-click mouse button the features within the drawn shape are automatically selected and highlighted in yellow. See Figure 5.30.

#### 5.5.2.4 CLEAR ALL SELECTION

This tool (see Figure 5.31) provides the user with the ability to clear all the selected features that result from using the previously discussed tools that are part of the Selection toolbar.

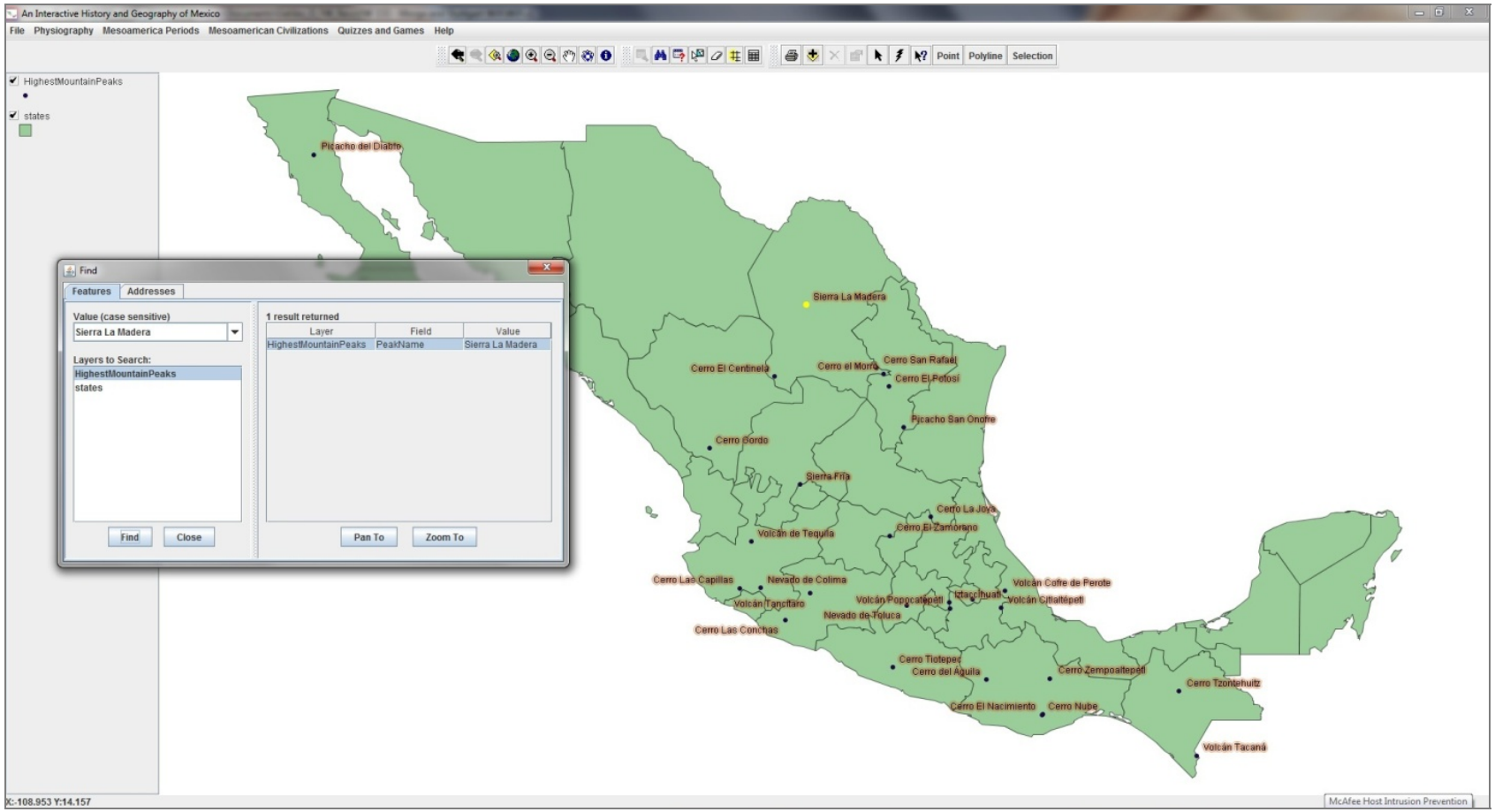



**Figure 5.25. Find tool's dialog. Dialog displayed when using the find tool with the input string: "Sierra La Madera." Notice how the feature found is highlighted on the map.**

**Figure 5.26. Query builder tool button.**

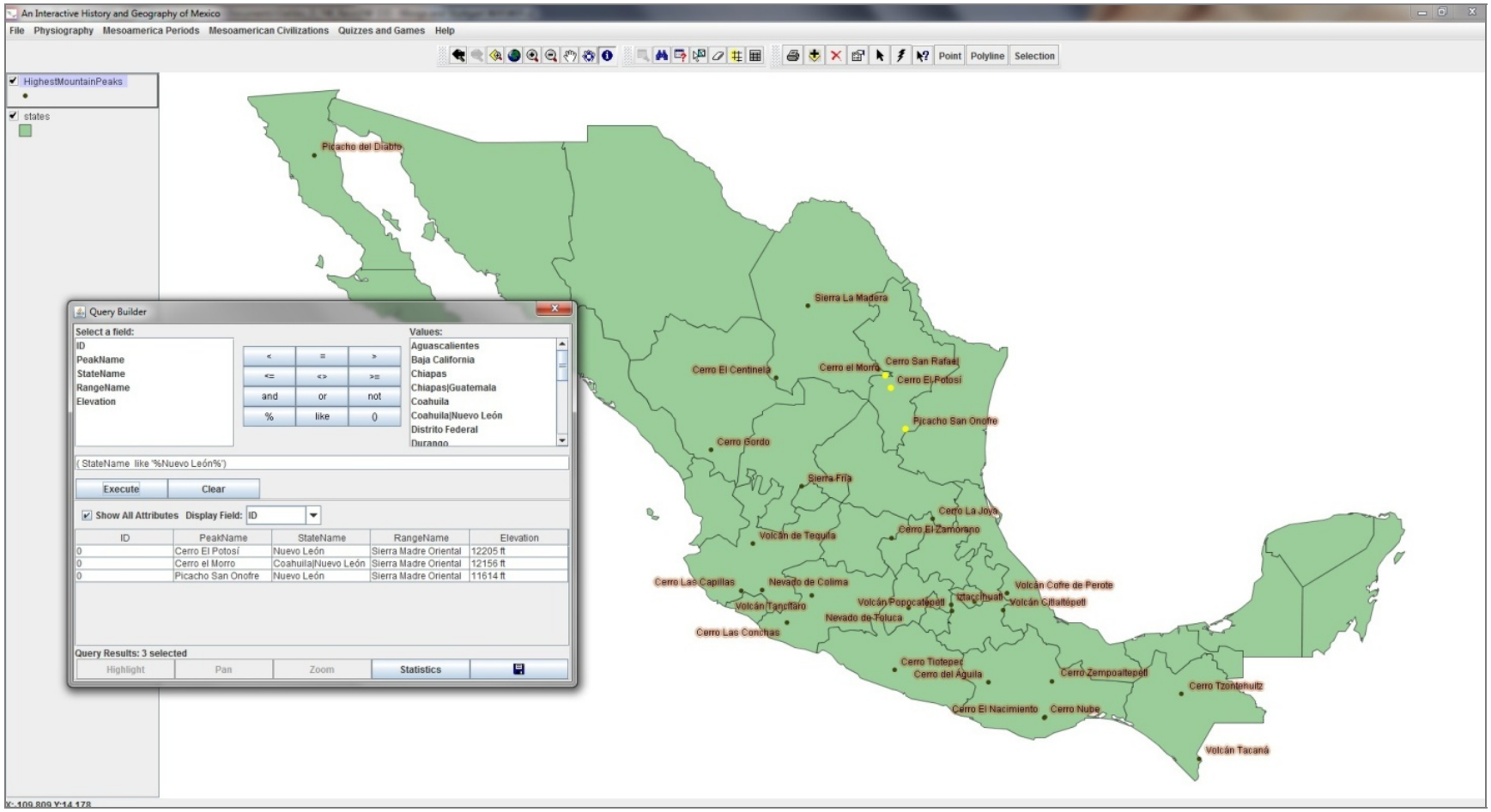



**Figure 5.27. Query builder tool's dialog. Dialog displayed when using the query builder tool with the SQL statement (StateName like '%Nuevo León%') which returns all the peaks located in the Mexican state of Nuevo León. Notice how all the peaks found in this state are highlighted in yellow.**

**Figure 5.28. Select features tool button.**

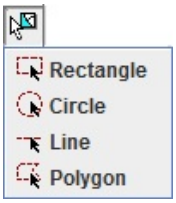



**Figure 5.29. Select features' drop down list.**

#### 5.5.2.5 BUFFER

Pressing this toolbar button (see Figure 5.32) opens a dialog for constructing a buffer polygon around the currently selected features. This dialog can be seen in Figure 5.33.

#### 5.5.2.6 ATTRIBUTES

This tool (see Figure 5.34) displays the attributes of the currently selected features. All the database records of the current layer are displayed in the table but only the records of the selected features are highlighted in blue. See Figure 5.35.

### 5.5.3 Customized Toolbar

The Customized Toolbar contains eleven buttons (see Figure 5.36). Their functionality is briefly described in this section.

#### 5.5.3.1 PRINT

This tool (see Figure 5.37) provides the user with the usual printing functionality found in most user applications. It calls the native print dialog used in the operating system. It prints the current map on display.

#### 5.5.3.2 ADD LAYER

This tool (see Figure 5.38) opens a dialog to be able to browse for the map layer (in SHP format) that wants to be added to the map currently displayed. See Figure 5.39.

After browsing and selecting the desired layer to be added to the map, the new layer is added, the map is refreshed and the legend for the new layer appears on top of the Table of Contents area, located to the left of the map. See Figure 5.40.

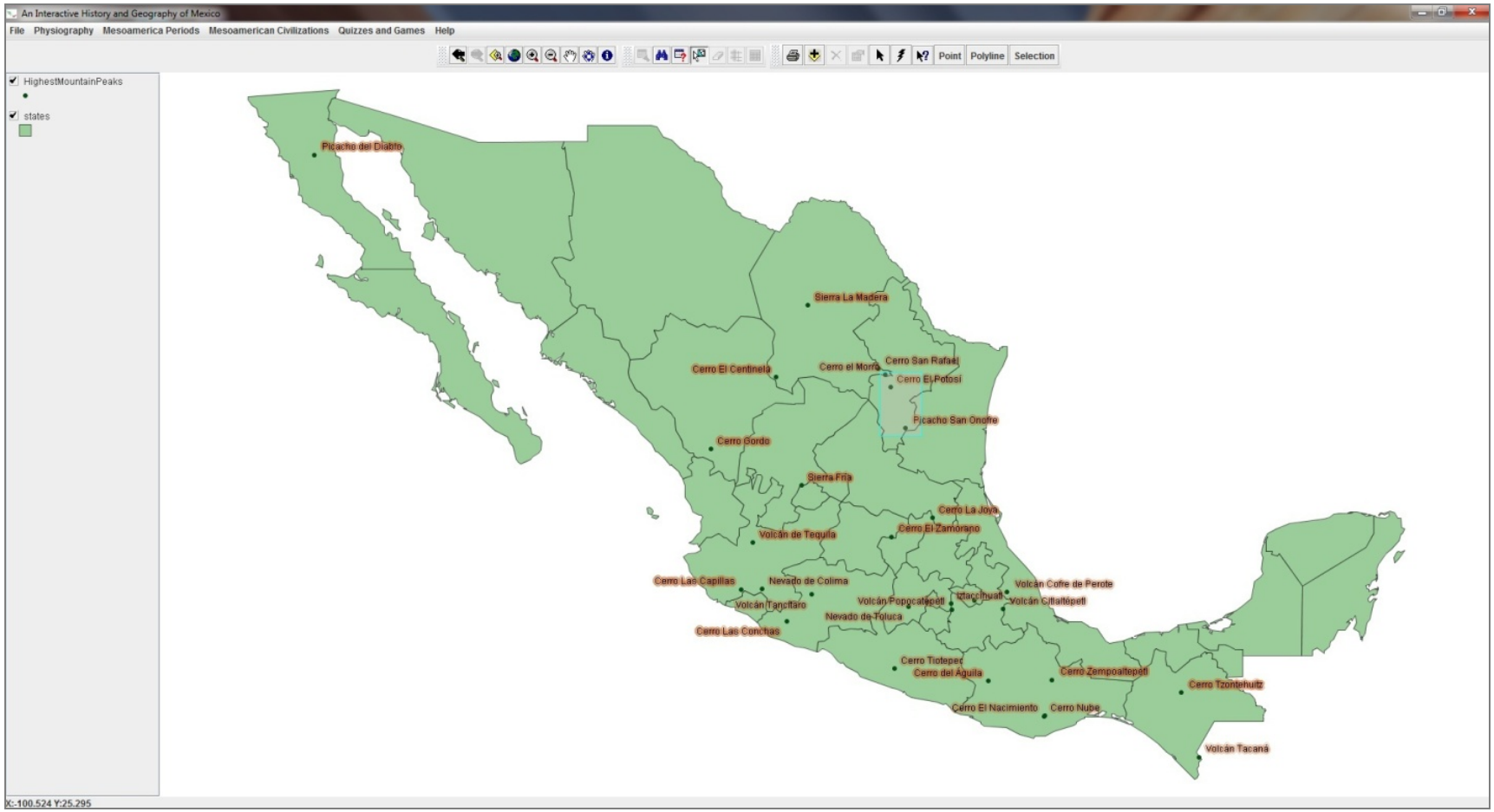



**Figure 5.30. Select features tool used to draw a rectangle. A rectangle shape is drawn on the map using the select features tool, to select all the peaks that are in the state of Nuevo León. When the mouse button is released all the selected features are highlighted in yellow and the rectangle disappears.**

**Figure 5.31. Clear all selection tool button.**

**Figure 5.32. Buffer tool button.**

#### 5.5.3.3 REMOVE LAYER

In order to use this tool (see Figure 5.41), the layer to be removed should be selected. To select a layer is necessary to click its legend on the table of contents area. After the layer is selected, pressing the Remove Layer button will automatically remove the layer, update the map and the table of contents.

#### 5.5.3.4 LEGEND EDITOR

This tool (see Figure 5.42) allows the user to modify the appearance of each layer that is part of the map currently displayed. The layer to be modified needs to be selected first. The legend editor provides the user with the option of modifying the layer's color and labels through a dialog with different tabs. See Figure 5.43 and 5.44.

#### 5.5.3.5 CURSOR (ARROW)

This tool (see Figure 5.45) provides a way for the user to unselect a map tool (that changes the shape of the cursor like Zoom In, Zoom Out, Pan, Identify, Hotlink and Help Tool) by changing the cursor back to the normal pointer.

#### 5.5.3.6 HOTLINK

This button (see Figure 5.46) provides the user with a tool (the cursor changes to a lightning bolt) to identify the features on the selected layer by clicking on them and displaying either a purely java constructed window containing further information about the feature or by displaying a picture of the feature and providing a web page link that contains other interesting information. The two types of hotlink windows created for this application can be seen in Figure 5.47 and Figure 5.48.

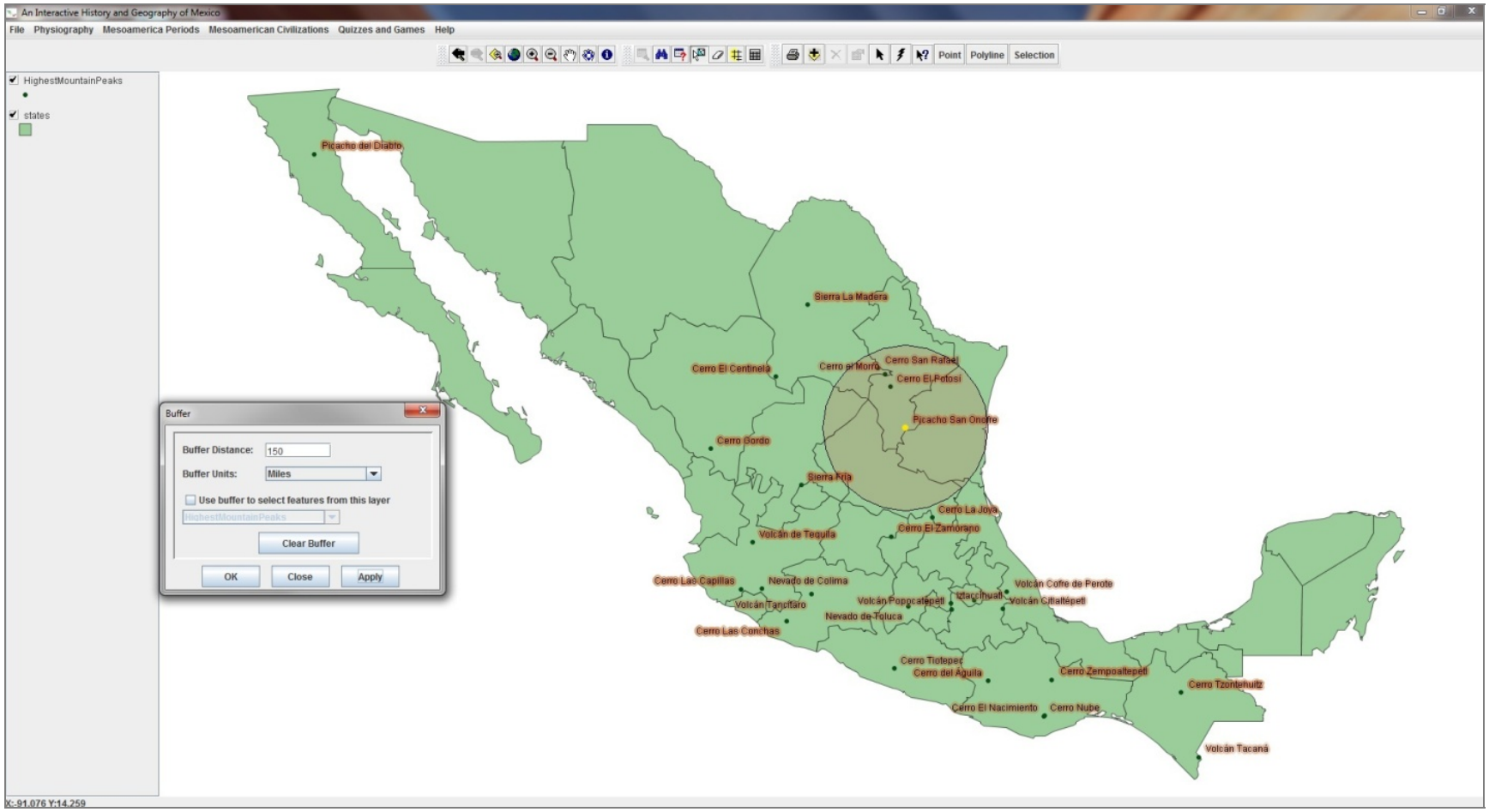



**Figure 5.33. Buffer tool's dialog. The buffer dialog provides a way to input the buffer distance based on the currently selected features. It also allows to decide if the features within the buffer zone need to be selected and therefore highlighted in yellow.**

**Figure 5.34. Attributes tool button.**

The Hotlink window seen in Figure 5.48 contains, at the bottom, a “Site Information” button. When pressed, this button will open a browser window with the appropriate web page created for the site. All the web pages created for this application have the format seen in Figure 5.49.

In order to unselect this tool, the arrow (cursor) tool button needs to be pressed (see section 5.5.3.5).

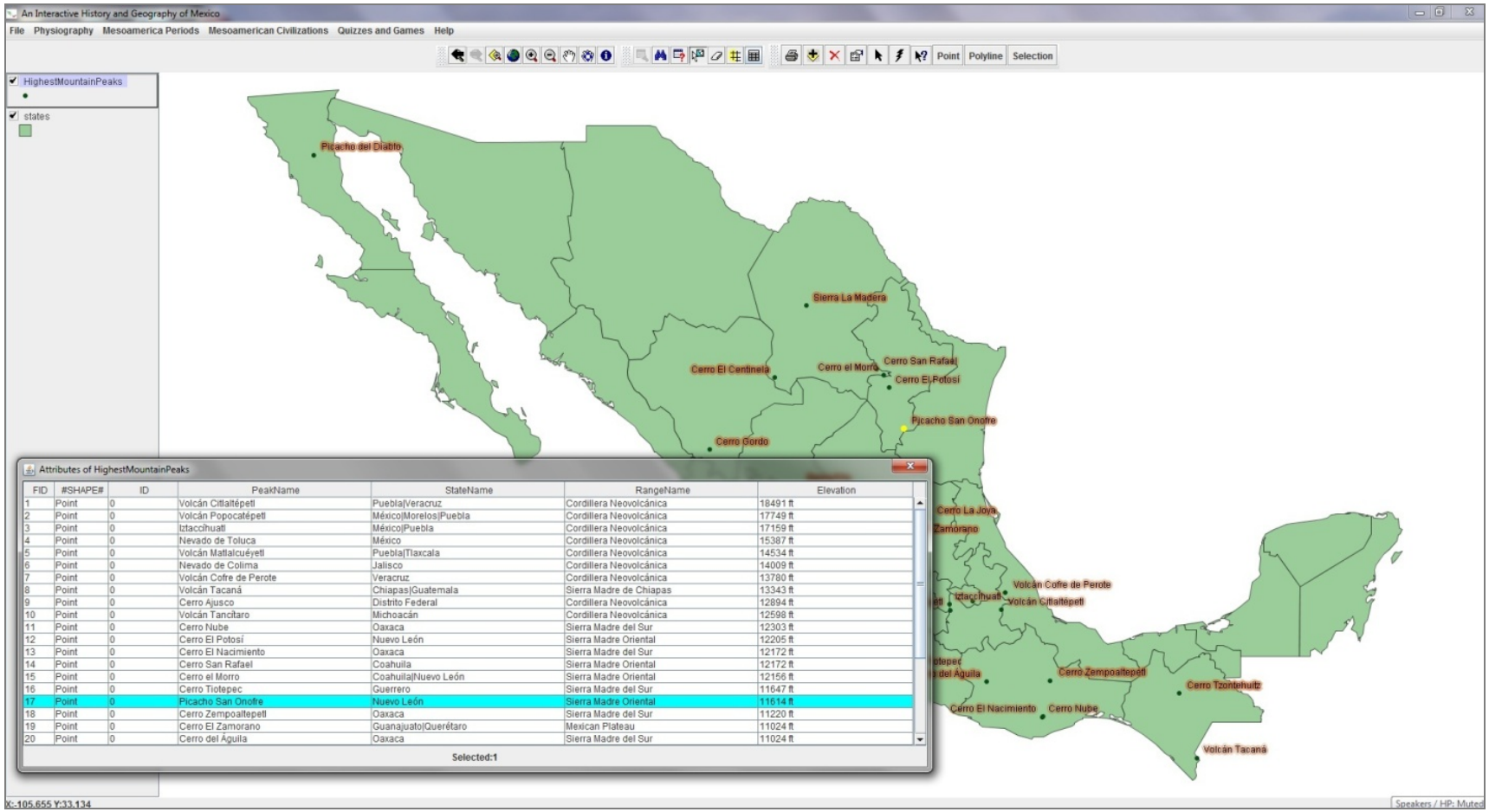
For both versions of this application (English and Spanish), audio files with the correct pronunciation of the archeological site’s name where added to the site’s web page to help especially non-Spanish speakers. To be able to listen to the audio file, the user has to click on the audio icon (see Figure 5.50). Javascript needs to be enabled on the web browser in order to use this feature. The web browser will display a message to let the user know about this. These audio files are also played every time the user clicks with the hotlink tool on a map’s feature, before either one of the two types of hotlink windows are displayed.

To generate the audio files in MP3 format, the Google translate tool [33] was used. This tool generates audio files based on an input query string. To force the Spanish pronunciation in the audio, Spanish characters, like the accent (á), were sometimes used to define the strong syllable and avoid an Anglicized pronunciation of the name.

The code snippet, seen in Figure 5.51, gives an idea on how the hotlink tool was integrated and implemented in this project.

In the code snippet (see Figure 5.51), based on the code found in the GISMexico Class, it can be seen that the Hotlink tool extends the functionality provided by the previously discussed Identify tool. A pick listener was added to the Hotlink tool in order to identify when a map feature is clicked on and display the appropriate information window.

In the code snippet, seen in Figure 5.52, part of the implementation for the PickAdapter class is presented. The method *foundData* identifies which layer the pick event occurred on and calls the appropriate method to display the information for the feature where the hotlink tool was used on.




Attributes of HighestMountainPeaks

| FID | #SHAPE# | ID | PeakName | StateName | RangeName | Elevation |
|---|---|---|---|---|---|---|
| 1 | Point | 0 | Volcán Citlaltépetl | Puebla\|Veracruz | Cordillera Neovolcánica | 18491 ft |
| 2 | Point | 0 | Volcán Popocatépetl | México\|Morelos\|Puebla | Cordillera Neovolcánica | 17749 ft |
| 3 | Point | 0 | Iztaccihuatl | México\|Puebla | Cordillera Neovolcánica | 17159 ft |
| 4 | Point | 0 | Nevado de Toluca | México | Cordillera Neovolcánica | 15387 ft |
| 5 | Point | 0 | Volcán Matlalcuéyetl | Puebla\|Tlaxcala | Cordillera Neovolcánica | 14534 ft |
| 6 | Point | 0 | Nevado de Colima | Jalisco | Cordillera Neovolcánica | 14009 ft |
| 7 | Point | 0 | Volcán Cofre de Perote | Veracruz | Cordillera Neovolcánica | 13780 ft |
| 8 | Point | 0 | Volcán Tacaná | Chiapas\|Guatemala | Sierra Madre de Chiapas | 13343 ft |
| 9 | Point | 0 | Cerro Ajusco | Distrito Federal | Cordillera Neovolcánica | 12894 ft |
| 10 | Point | 0 | Volcán Tancítaro | Michoacán | Cordillera Neovolcánica | 12598 ft |
| 11 | Point | 0 | Cerro Nube | Oaxaca | Sierra Madre del Sur | 12303 ft |
| 12 | Point | 0 | Cerro El Potosí | Nuevo León | Sierra Madre Oriental | 12205 ft |
| 13 | Point | 0 | Cerro El Nacimiento | Oaxaca | Sierra Madre del Sur | 12172 ft |
| 14 | Point | 0 | Cerro San Rafael | Coahuila | Sierra Madre Oriental | 12172 ft |
| 15 | Point | 0 | Cerro el Morro | Coahuila\|Nuevo León | Sierra Madre Oriental | 12156 ft |
| 16 | Point | 0 | Cerro Tiotepec | Guerrero | Sierra Madre del Sur | 11647 ft |
| 17 | Point | 0 | Picacho San Onofre | Nuevo León | Sierra Madre Oriental | 11614 ft |
| 18 | Point | 0 | Cerro Zempoaltepetl | Oaxaca | Sierra Madre del Sur | 11220 ft |
| 19 | Point | 0 | Cerro El Zamorano | Guanajuato\|Querétaro | Mexican Plateau | 11024 ft |
| 20 | Point | 0 | Cerro del Águila | Oaxaca | Sierra Madre del Sur | 11024 ft |

Selected:1

**Figure 5.35. Attributes table. The record of the selected feature on the map, in this case “Picacho San Onofre” (seen in yellow on the map), is highlighted in blue in the displayed attributes table for the mountain peaks layer.**

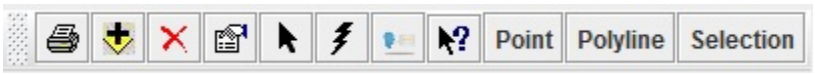



**Figure 5.36. Customized toolbar.**

**Figure 5.37. Print tool button.**

**Figure 5.38. Add layer tool button.**

#### 5.5.3.7 SELECT LANGUAGE TOOL

With this tool (see Figure 5.53) the user will be able to switch between the English and Spanish version of the program, once the application is already running.

#### 5.5.3.8 HELP TOOL

With this tool (see Figure 5.54), the user will be able to right-click on a tool button and see a help window pop up with information on how that tool works. See Figure 5.55.

When using this tool the cursor will change its shape into a pointer with a question mark to the side. To unselect the Help Tool, and go back to the normal cursor shape, the Cursor tool button needs to be pressed (see section 5.5.3.5).

#### 5.5.3.9 CREATE POINT LAYER

This button (see Figure 5.56) was the GUI (Graphical User Interface) used to run the code implemented for the creation of point layers described in section 5.4.1 This button opens a dialog to browse for the appropriate CSV file.

This functionality was only enabled on the development stage in order to create all the point layers for this application. It will not be enabled for the end users of this program because it requires a little more understanding of how GIS data is generated.

#### 5.5.3.10 CREATE POLYLINE LAYER

This button (see Figure 5.57) was the GUI (Graphical User Interface) used to run the code implemented for the creation of polyline layers described in section 5.4.2. This button opens a dialog to browse for the appropriate CSV file.

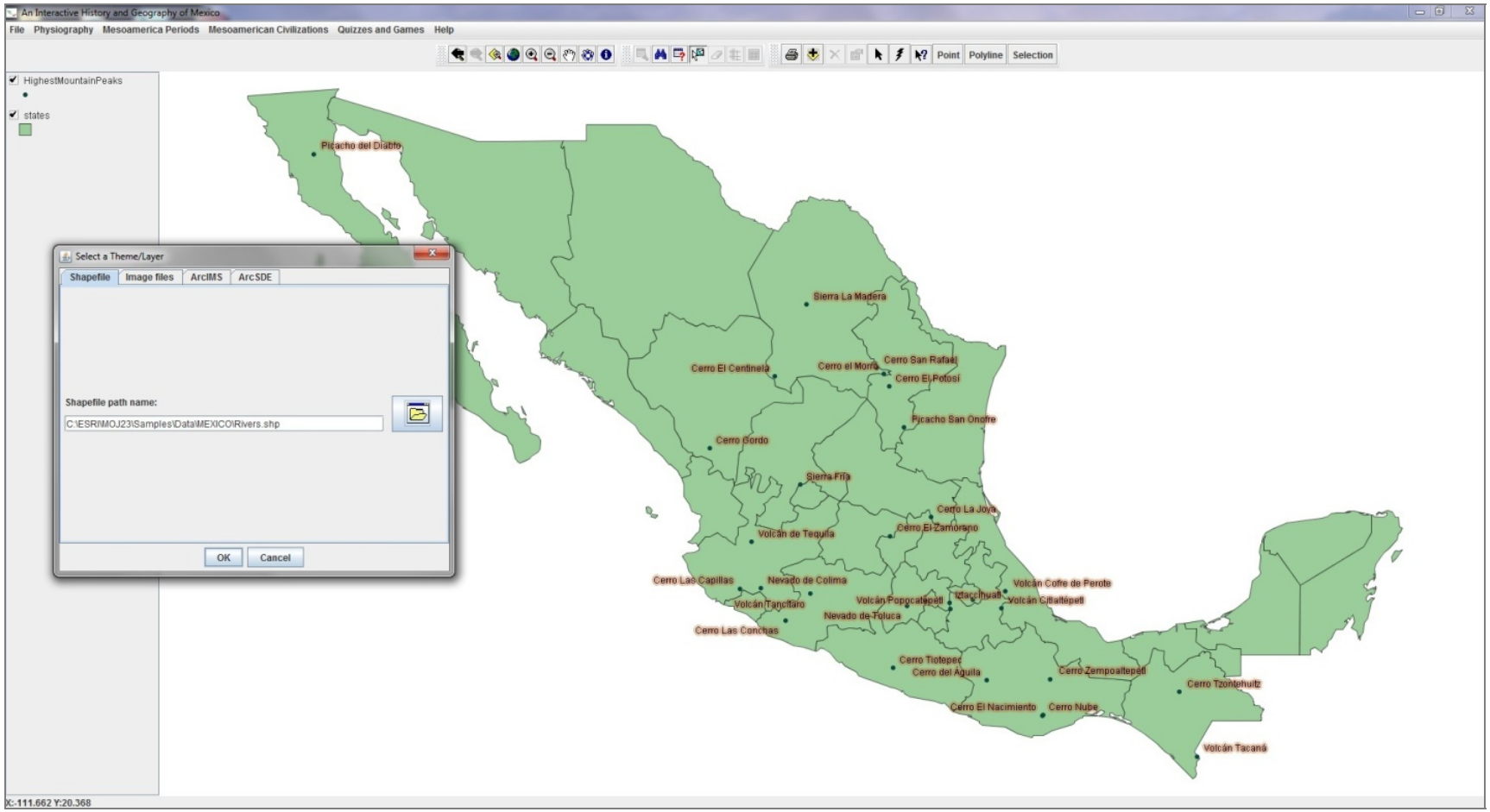



**Figure 5.39. Add layer dialog. This dialog allows the user to select the new layer to be added to the current map. The Mexican Rivers layer is the layer about to be added, in this case.**

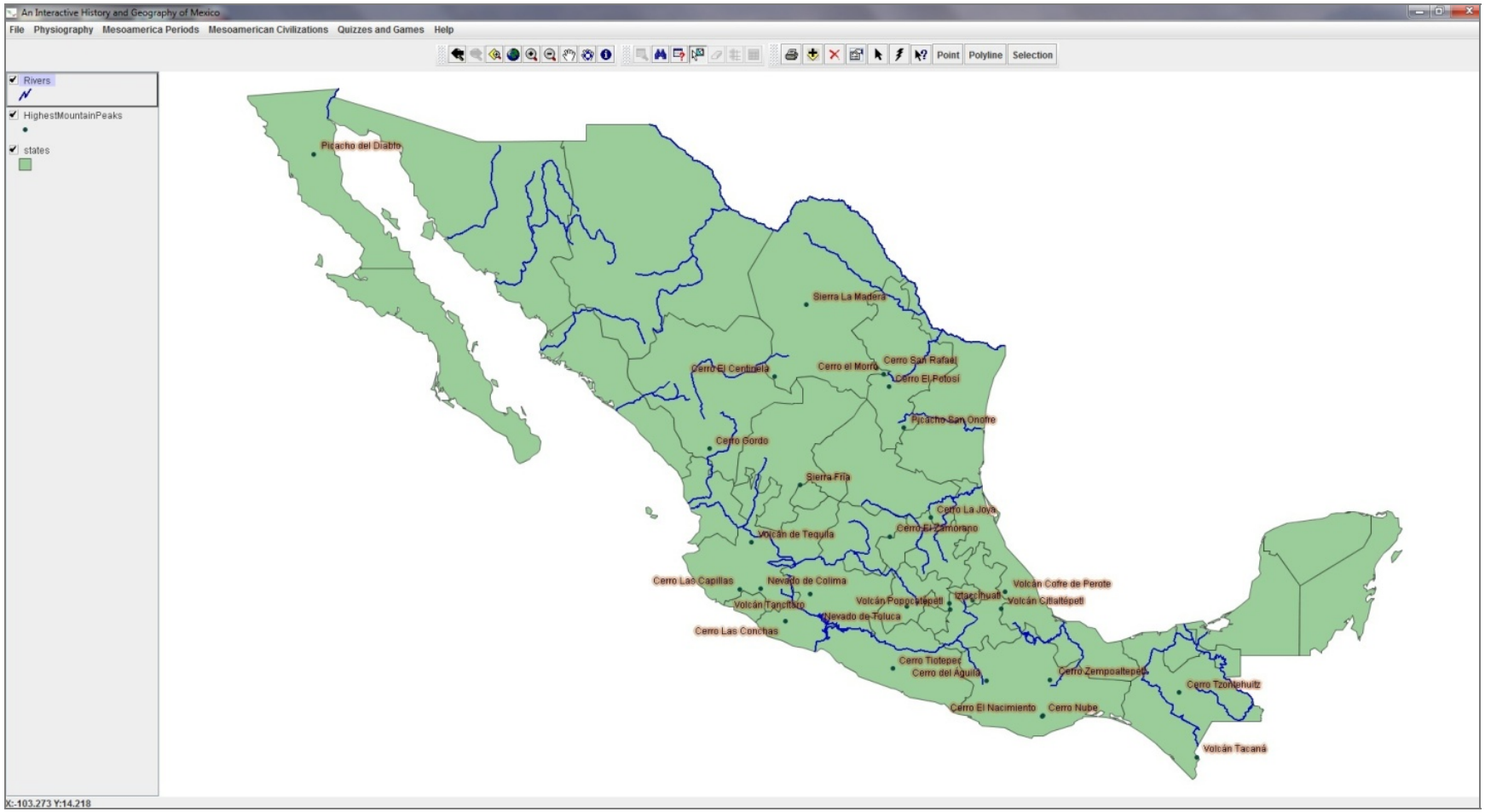



**Figure 5.40. Map of the highest mountain peaks after adding the main rivers layer. The map and the table of contents are updated.**

**Figure 5.41. Remove layer tool button.**

**Figure 5.42. Legend editor tool button.**

This functionality was only enabled on the development stage for the same reasons described above.

#### 5.5.3.11 CREATE LAYER FROM SELECTION

This button (see Figure 5.58) was the GUI (Graphical User Interface) used to run the code implemented for the creation of layers from a selection of GIS Data, this process was described in section 5.4.3. This button automatically creates a layer from a selection of the data that its part of the current layer, based on a provided SQL query.

This functionality was only enabled on the development stage for the same reasons described in sections 5.5.3.9 and 5.5.3.10.

## 5.6 APPLICATION'S MENUS

This application has six main menus. In the next few sections these menus will be briefly discussed.

### 5.6.1 File

The File menu (see Figure 5.59) provides access to basic functions that can be performed on the current map: Add Layer, Remove Layer, Legend Editor, Language Options, Print and Exit. These menu items (except for "Exit" that has no button on the toolbar) provide the same functionality than that provided by the tool buttons of the same name described in section 5.5.3. Having these functions as menu items gives the user another way of accessing the same functionality.

### 5.6.2 Physiography

The Physiograhy menu (see Figure 5.60) provides the user with access to Mexico's Hydrographic and Topographic Maps. In the Topographic sub-menu, the maps for the main

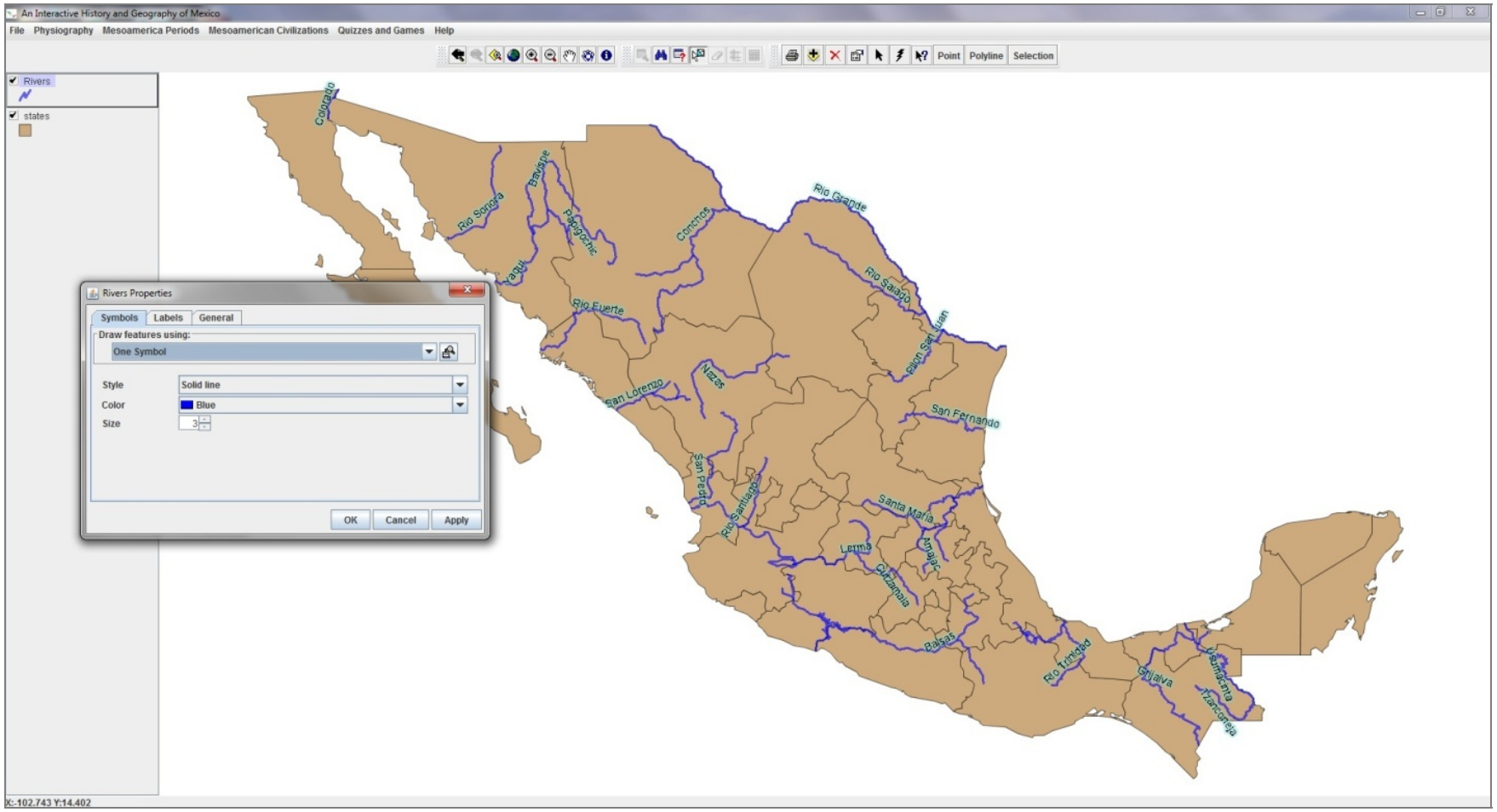



**Figure 5.43. Legend editor's dialog tab to format features. The selected layer is the rivers layer (a polyline layer), so the type, the color and the thickness of the line can be modified.**

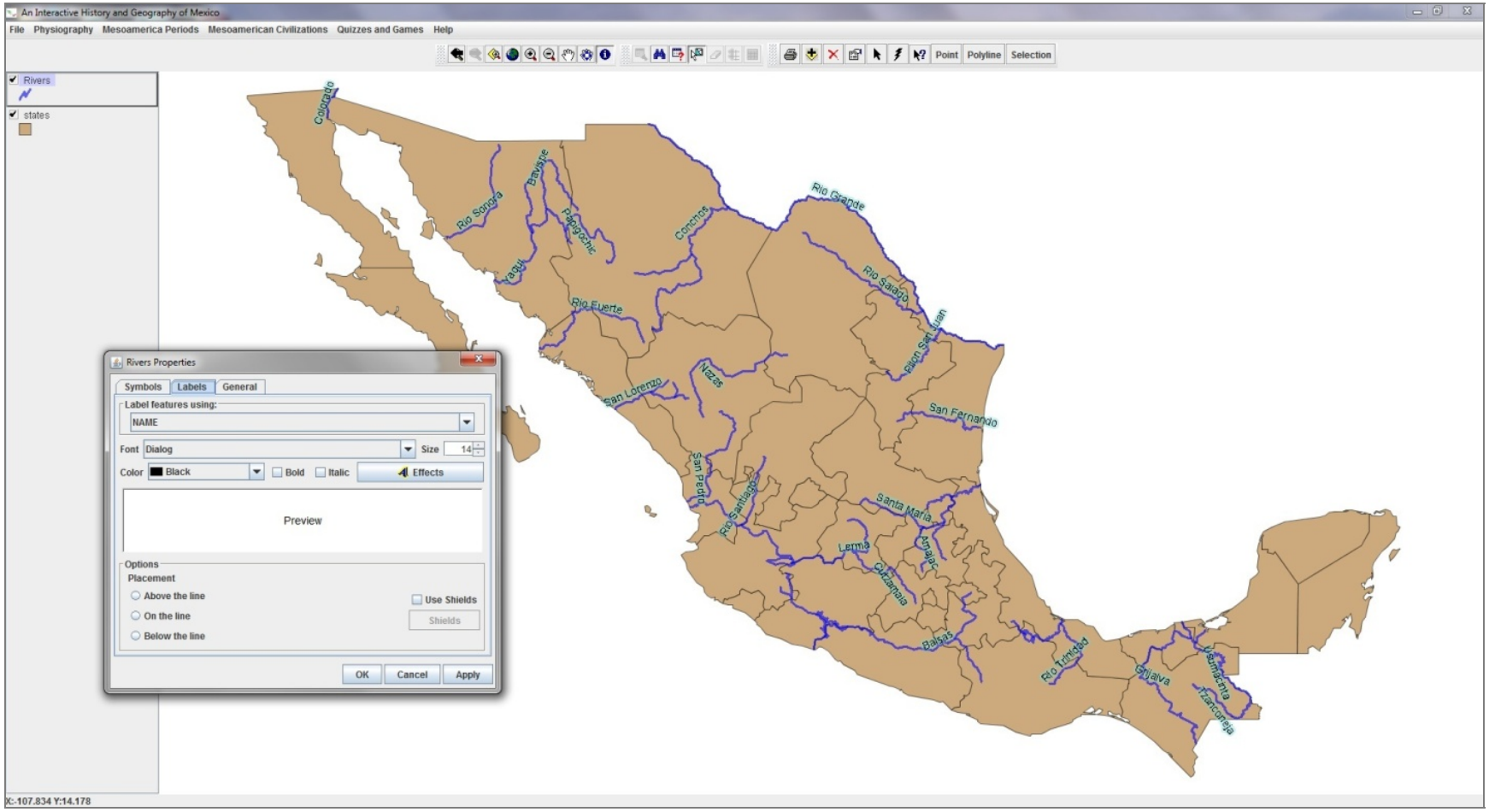



**Figure 5.44. Legend editor's dialog tab to format labels. The formatting includes the label's position from the feature's perspective.**

**Figure 5.45. Cursor (arrow) tool button.**

**Figure 5.46. Hotlink tool button.**

mountain peaks (see Figure 5.6) and the main mountain ranges (see Figure 5.61) in Mexico can be seen. In the Hydrographic sub-menu the maps for the main rivers (see Figure 5.62) and the main lakes (see Figure 5.63) in Mexico can be accessed.

### 5.6.3 Mesoamerica Periods

This menu (see Figure 5.64) provides the user with access to different Mesoamerica's maps that illustrate the main archeological sites in the region depending on the period. For each period (Pre-Classic, Classic, Post-Classic) there's a corresponding menu item. See Figure 5.65.

There's also the menu item, "Mesoamerica Timeline", that provides the user with an interactive timeline based on the main archeological sites founded during Mesoamerica's history. See Figure 5.66.

### 5.6.4 Mesoamerican Civilizations

This menu (see Figure 5.67) provides the user with access to different Mesoamerica's Civilizations maps that illustrate the area that each one used to cover as well as the main sites that were founded by each group (see Figure 5.68). This menu also provides access to a map that shows the region covered by Mesoamerica's cultures (see Figure 5.9). A dynamic timeline is also available, the map layers change as the user interacts with it (see Figure 5.69).

### 5.6.5 Quizzes and Games

This menu (see Figure 5.70) provides the user with access to a couple of quizzes and games about Mesoamerica's history. The purpose of this menu is to provide the students with a way to assimilate all the lessons learned in a more fun way.

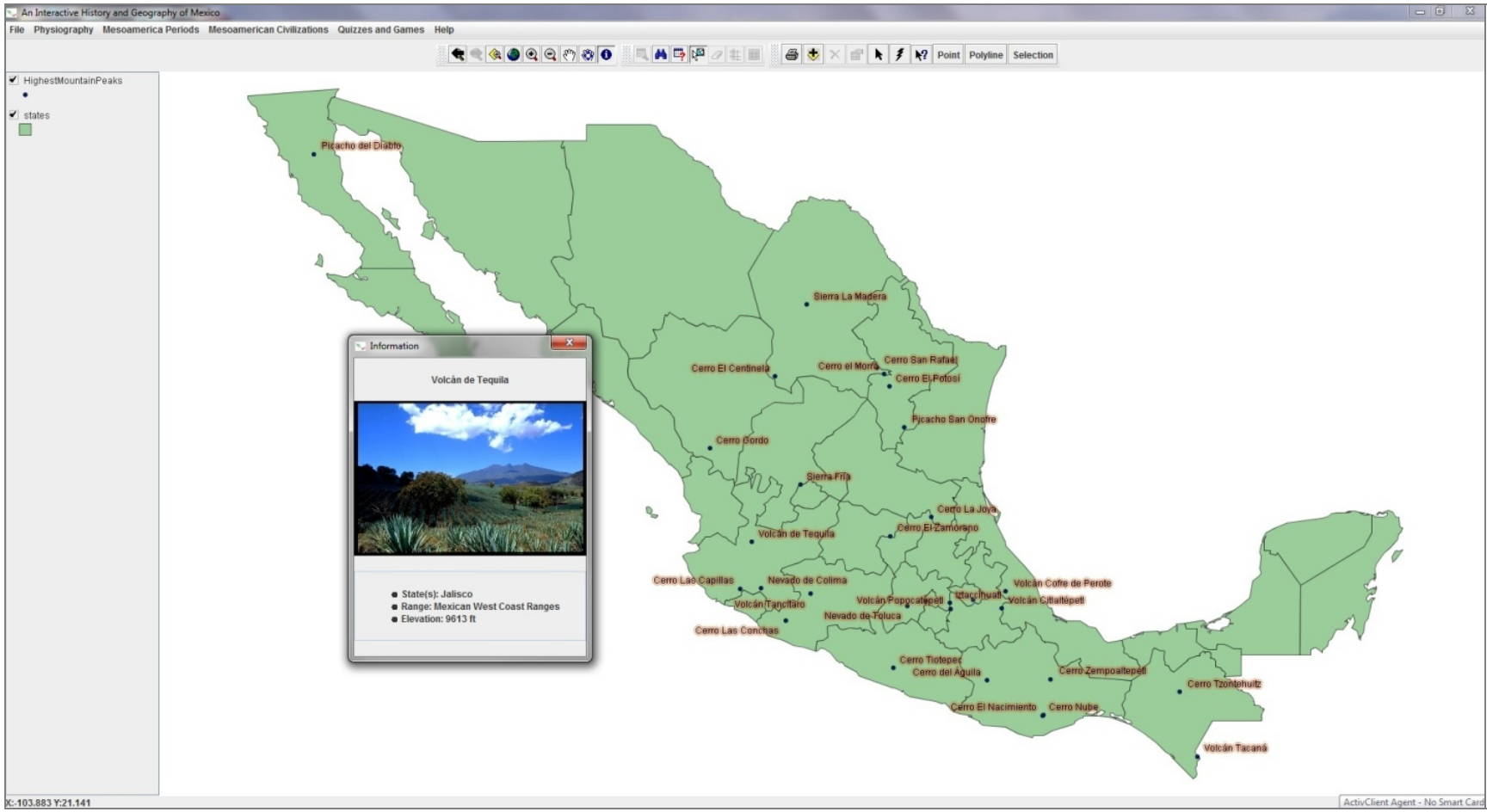



**Figure 5.47. Hotlink tool used on the highest mountain peak's map. The  tool is used to identify the peak "Volcán de Tequila". The type of Hotlink window, shown in the image, is used for physiographic features (rivers, lakes, peaks and ranges).**

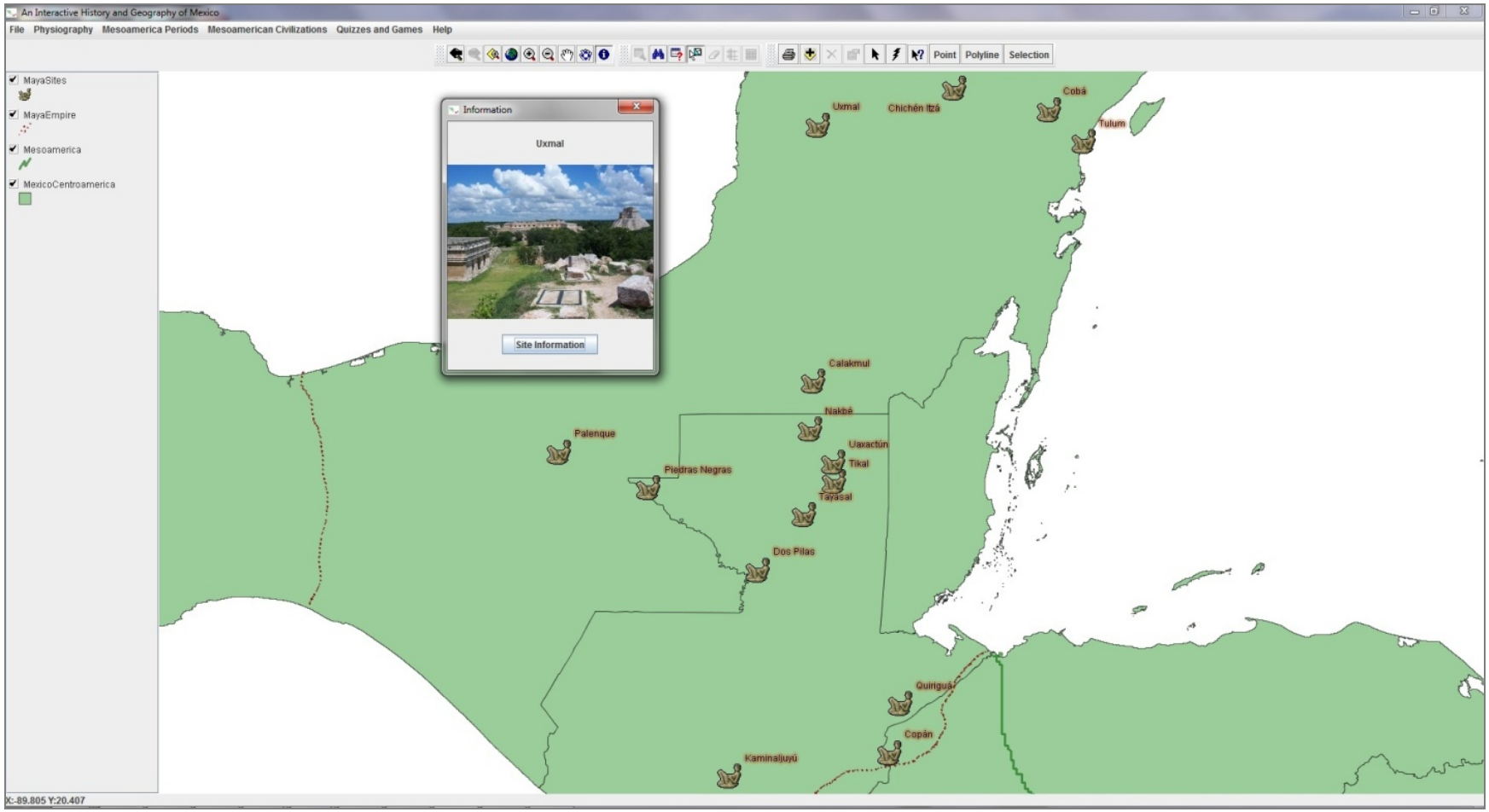



**Figure 5.48. Hotlink tool used on the main Mayan site's map. The tool is used to identify the ancient site of "Uxmal". The type of hotlink window, shown in the image, is used for archeological features. Notice the button "Site Information".**

An Interactive History and Geography of Mexico
File Physiography Mesoamerica Periods
MayaSites
MayaEmpire
Mesoamerica
MexicoCentroamerica
C:\ESRI\MOJ23\GISMexico\GISMex
MapObjects - Java Programme...
GIS Mexico - Maya Site: Ux...
McAfee
Convert
Select
Find:
Previous
Next
Options
Maya site - Uxmal
Mesoamerica: Maya site>> Uxmal
Uxmal
Uxmal (500 AD - 1550 AD) is an ancient Mayan city of the classical period. Today is one of the most important archaeological sites of Mayan culture, along with those of Chichen Itza and Tikal. It is located 62 km south of Mérida, capital of Yucatán state in Mexico.
Uxmal's buildings are typical of the Puuc arquitectural style, with smooth low walls that open on ornate friezes based on representations of typical Mayan huts, which are represented by columns and trapezoidal shapes, entwined snakes and, in many cases two-headed snakes, masks of the rain god, Chaac, with its big noses that represent the rays of the storms, and feathered serpents with open fangs leaving from the same human beings.
Some of the most important buildings at the site include the Pyramid of the Magician, with five levels, the Governor's Palace which covers an area of more than 1.200m², the Government palace and a large ballcourt for playing the Mesoamerican ballgame.
Most of the city's major construction took place while Uxmal was the capital of a Late Classic Mayan state around 850-925 AD, though after about 1000 AD, Toltec invaders took over and most building ceased by 1100 AD.
For generations Uxmal was ruled over by the Xiu family, it was the most powerful site in western Yucatán, and for a while in alliance with Chichen Itza dominated all of the northern Maya area. Sometime after about 1200 no new major construction seems to have been made at Uxmal, possibly related to the fall of Uxmal's ally Chichen Itza and the shift of power in Yucatán to Mayapán. The Xiu moved their capital to Maní, and the population of Uxmal declined.
After the Spanish conquest of Yucatán (in which the Xiu allied themselves with the Spanish), early colonial documents suggest that Uxmal was still an inhabited place of some importance into the 1550s, but no Spanish town was built here and Uxmal was soon after largely abandoned.
Tulum
Copán
Kaminaljuyú
X:-89.805 Y:20.407

**Figure 5.49. Archeological site's web page. Web page displayed when clicking on the "Site Information" button seen in Figure 5.48. Notice the audio icon (see Figure 5.50) to the right of the archeological site's name.**

**Figure 5.50. Audio icon.**

```
//Code snippet from GISMexico Main Class
private Identify hotlink = new Identify();

GISMexicoPickAdapter  pickListener = new GISMexicoPickAdapter(selectedLanguage, this);
 hotlink.addPickListener(pickListener);
 hotlink.setPickWidth(40);
hotlink.setSelectedLayer(activeLayer);

JButton hotlinkButton = new JButton(new ImageIcon(HOTLINK_ICON));
gisToolBar.add(hotlinkButton);
```

**Figure 5.51. Code snippet to integrate the hotlink tool to the application.**

```
//Code snippet from the GISMexicoPickAdapter Class
public void foundData(PickEvent pickEvent)
{
  FeatureLayer featureLayer =(FeatureLayer)pickEvent.getLayer();
  …
  else if(featureLayer.getName().equals(messages.getString("MayaSites")))
    displayMayaSitesInfo(pickEvent);
  …
}
public void displayMayaSitesInfo(PickEvent pickEvent)
 {
   Feature feature = null;
   Fields fields;
   com.esri.mo2.data.feat.Cursor cursor = pickEvent.getCursor();
   if(cursor != null)
   feature = (Feature)cursor.next();
   fields = feature.getFields();
   String siteName = (String)feature.getValue(2);
   …
   else if(siteName.equals("Uxmal"))
          {
             HotlinkWindow hotlinkWindow = new
                    HotlinkWindow(GISMexico.HTML_DATA_DIRECTORY_PATH +
                    messages.getString("UxmalFilename")+ ".html", siteName,
                    GISMexico.HTML_IMAGES_DIRECTORY_PATH + "Uxmal.jpg", ownerFrame,
                    messages);
             hotlinkWindow.setVisible(true);
          }
}
```

**Figure 5.52. Code snippet from the hotlink's pick adapter class.**

**Figure 5.53. Select language tool button.**

**Figure 5.54. Help tool button.**

The quizzes will get graded after the student completes them and the correct answers in comparison with the given answers, will be highlighted. Depending on the game, the questions will be graded on a per “question” basis. See Figure 5.71 and 5.72.

### 5.6.6 Help

This menu (see Figure 5.73) provides the user with access to a “Quick Start Guide” on how to use this application. It also provides some information about the developer, the version of the program and a copyright notice. See Figure 5.74.

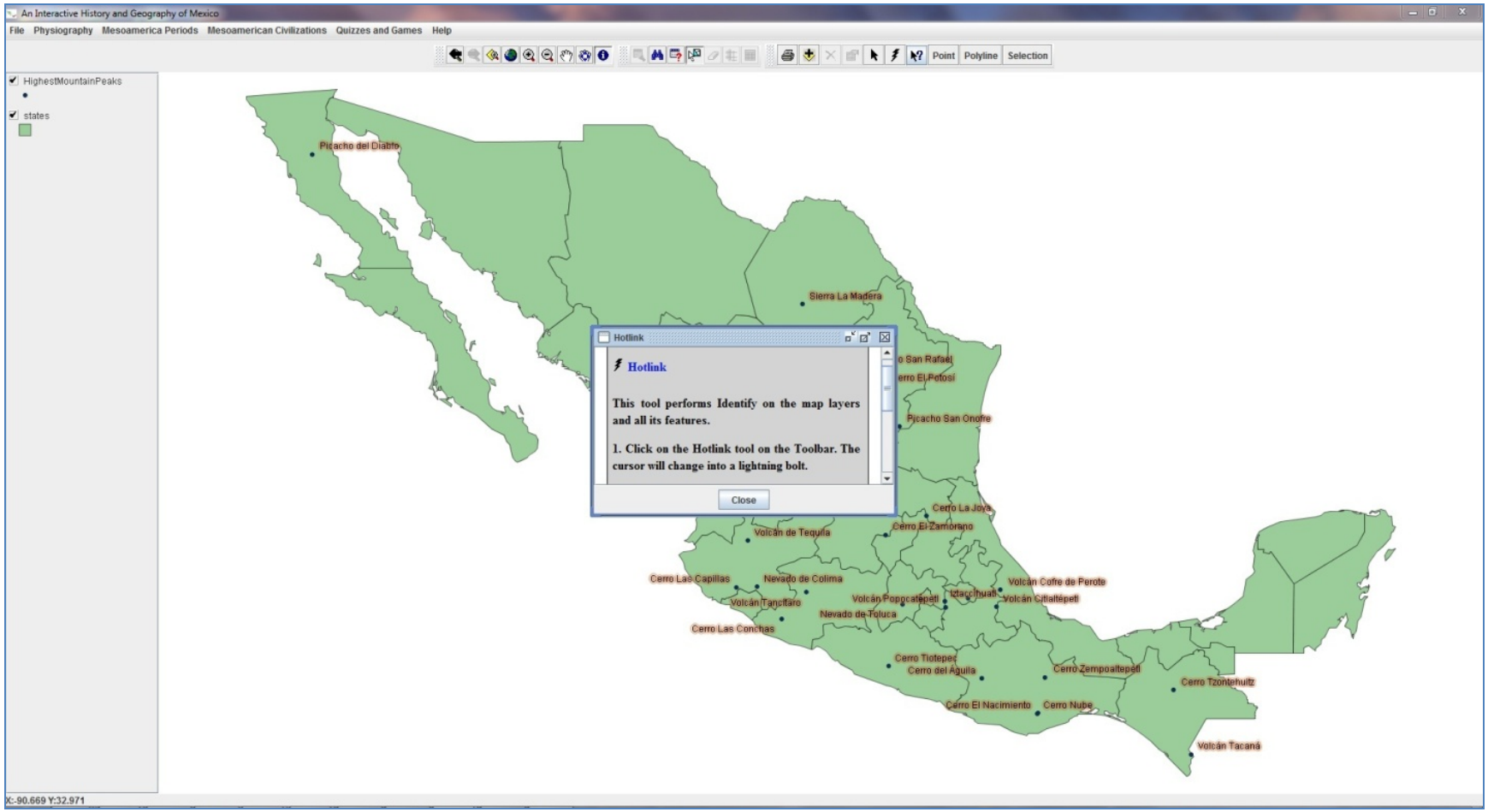



**Figure 5.55. Help tip window. Window displayed when the help tool is used on the hotlink button.**

**Figure 5.56. Create point layer tool button.**

**Figure 5.57. Create polyline layer tool button.**

**Figure 5.58. Create layer from selection tool button.**

**Figure 5.59. File menu.**

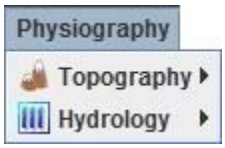



**Figure 5.60. Physiography menu.**

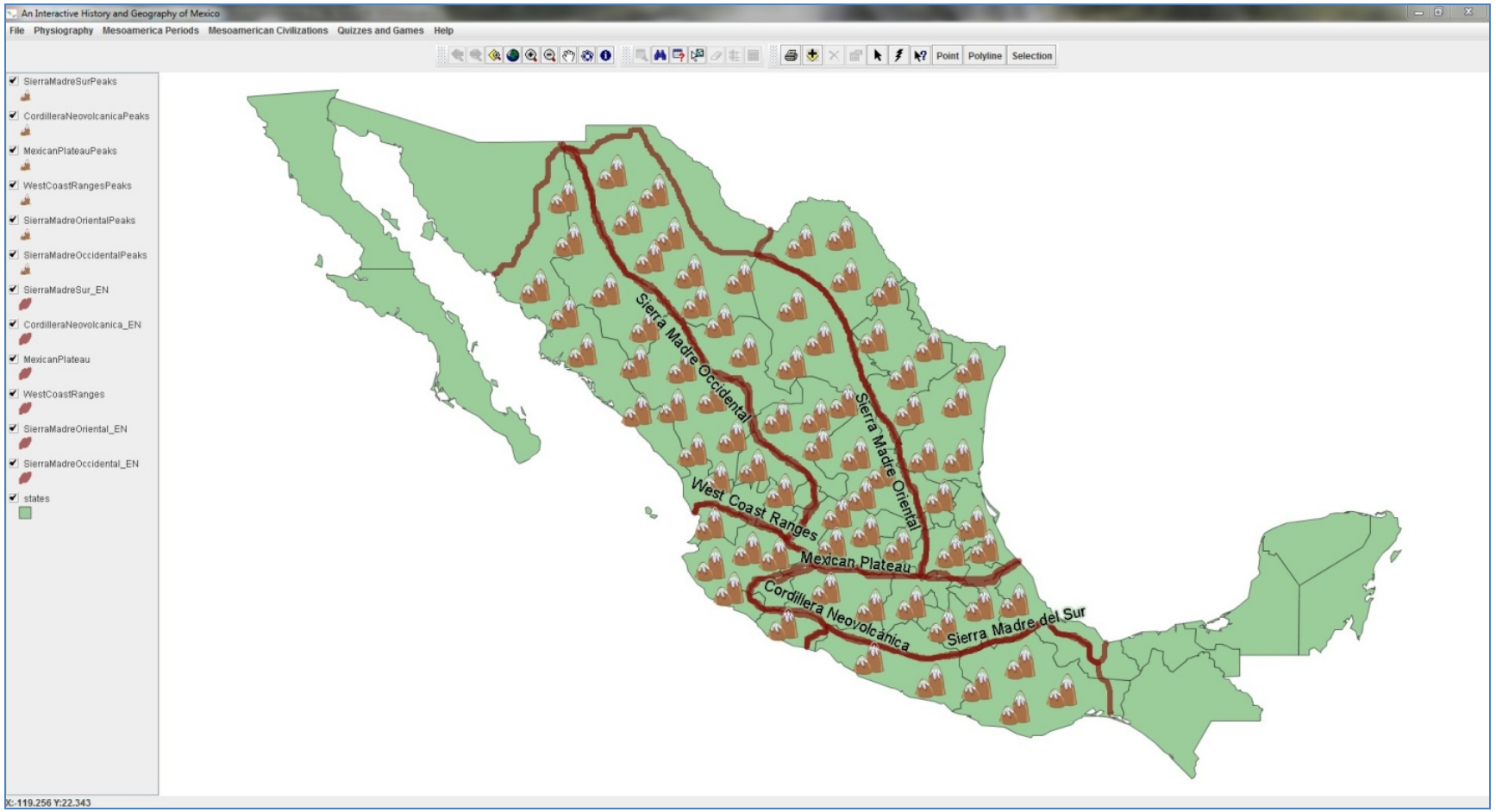



**Figure 5.61. Main mountain ranges in Mexico map. Accessed from "Topography" sub-menu.**

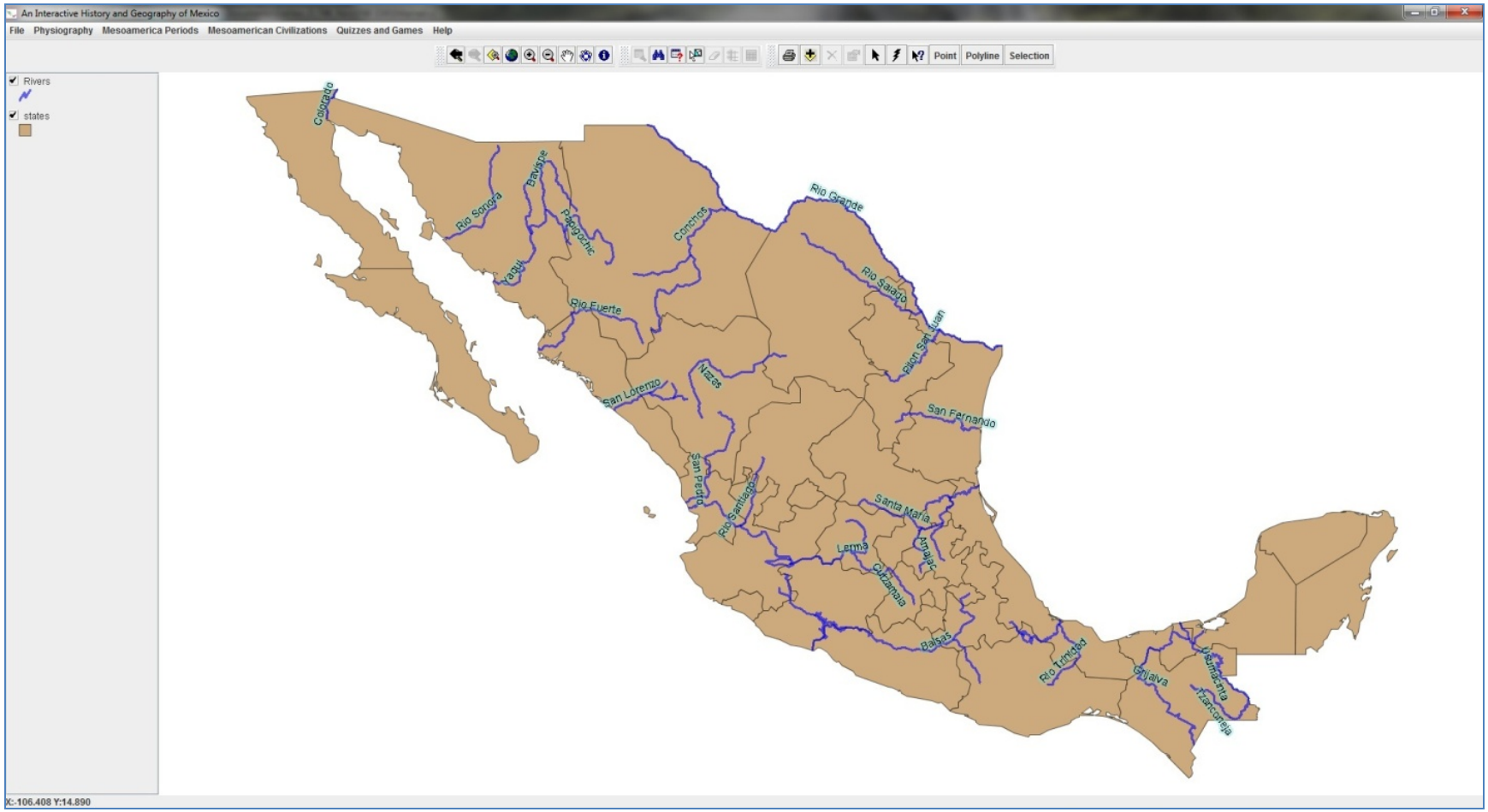



**Figure 5.62. Main rivers in Mexico map. Accessed from “Hydrography” sub-menu.**

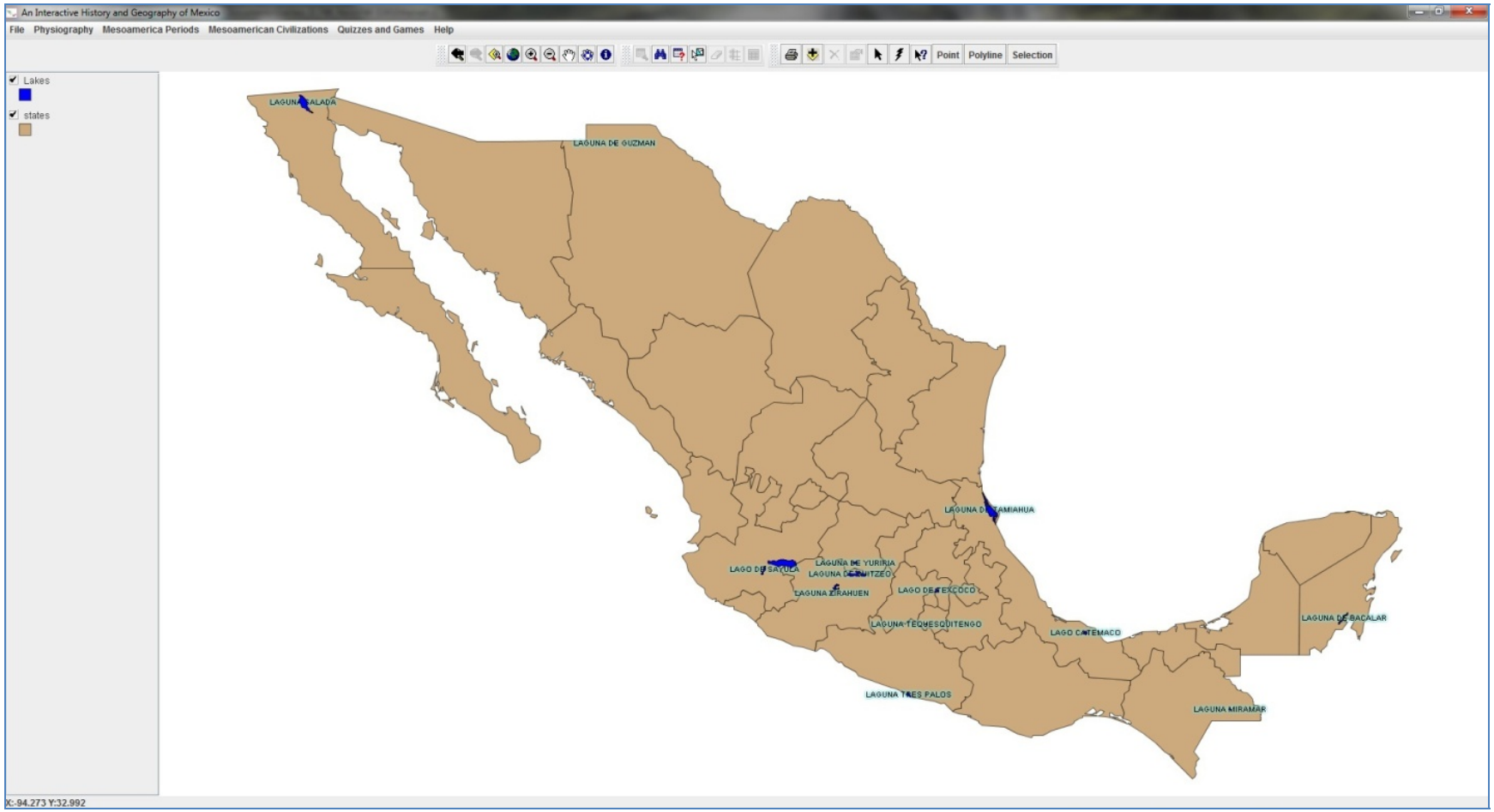



**Figure 5.63. Main lakes in Mexico map. Accessed from “Hydrography” sub-menu.**

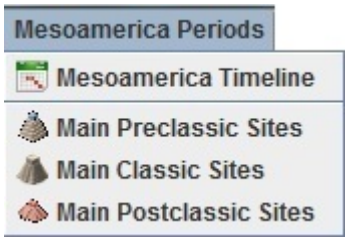



**Figure 5.64. Mesoamerica periods menu.**

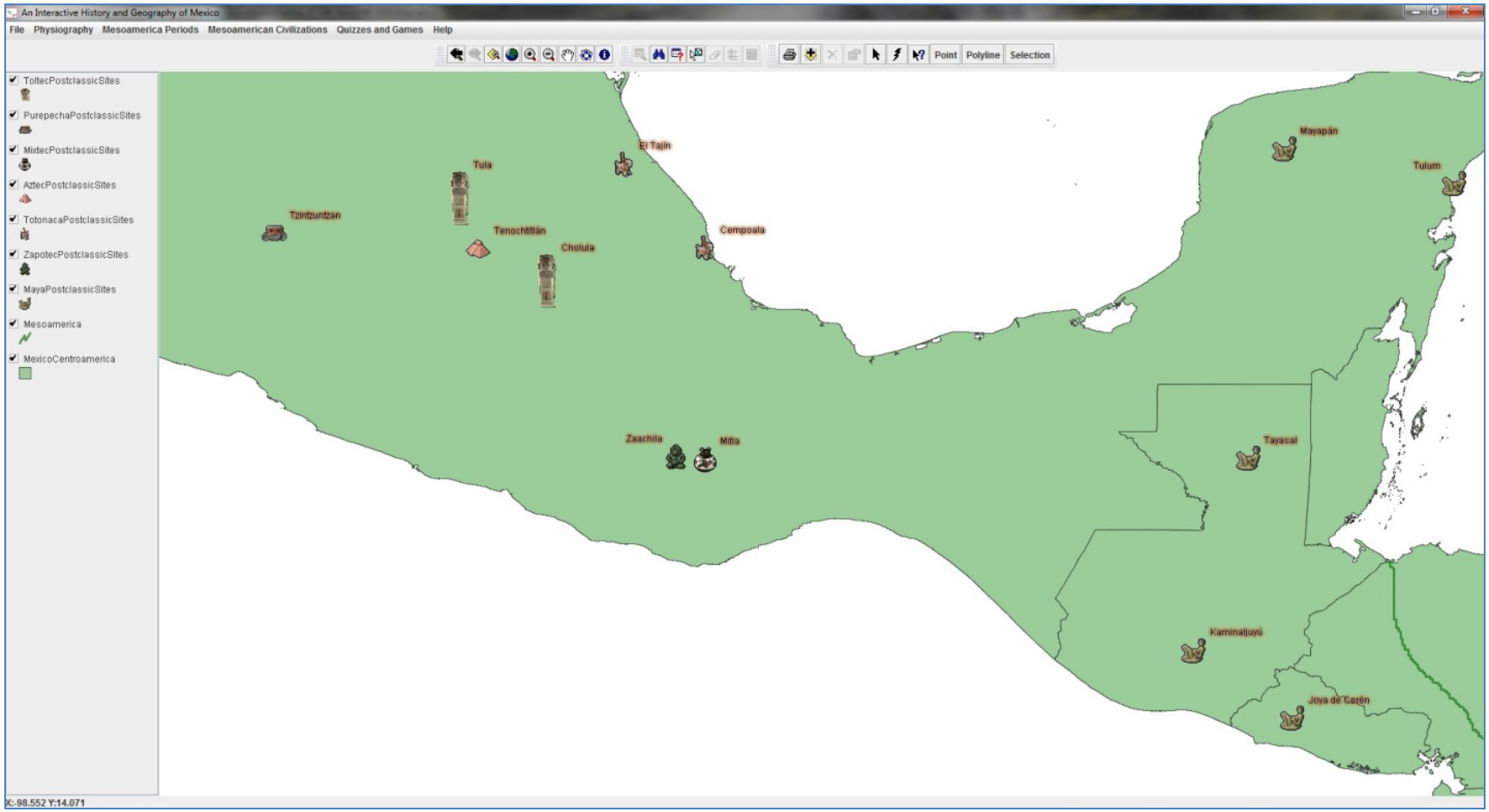



**Figure 5.65. Main post-classic sites in Mesoamerica. Maps for the main pre-classic and classic sites are also accessed from the "Mesoamerica Periods" menu.**

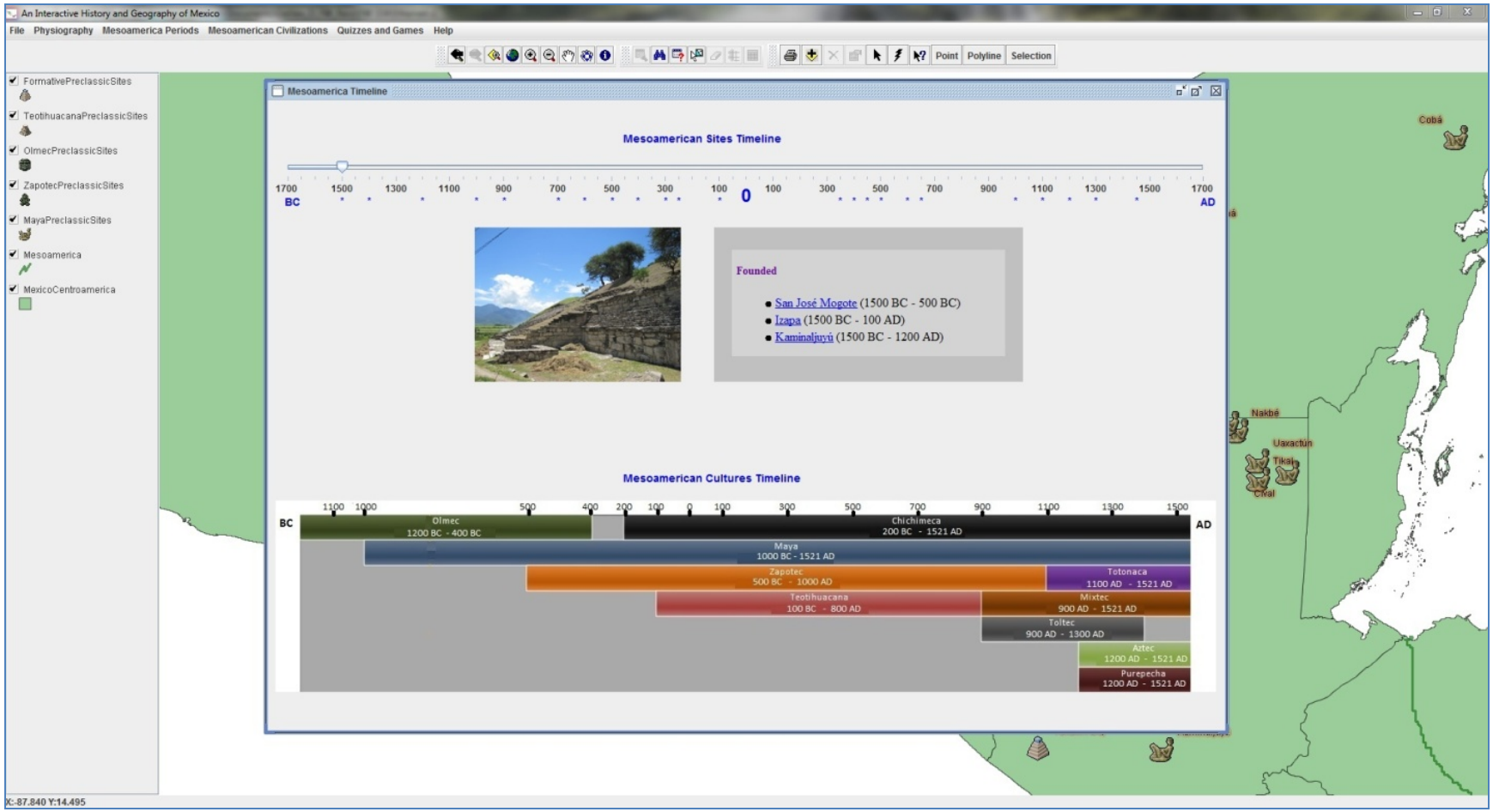



**Figure 5.66. Mesoamerica's sites timeline.**

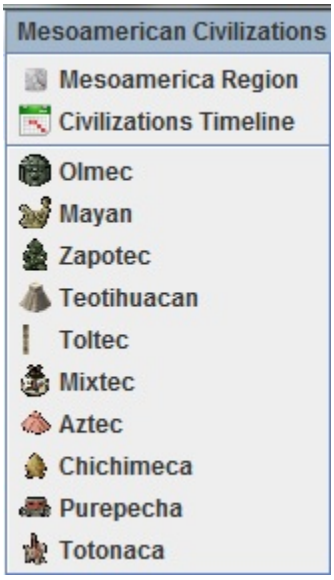



**Figure 5.67. Mesoamerican civilizations menu.**

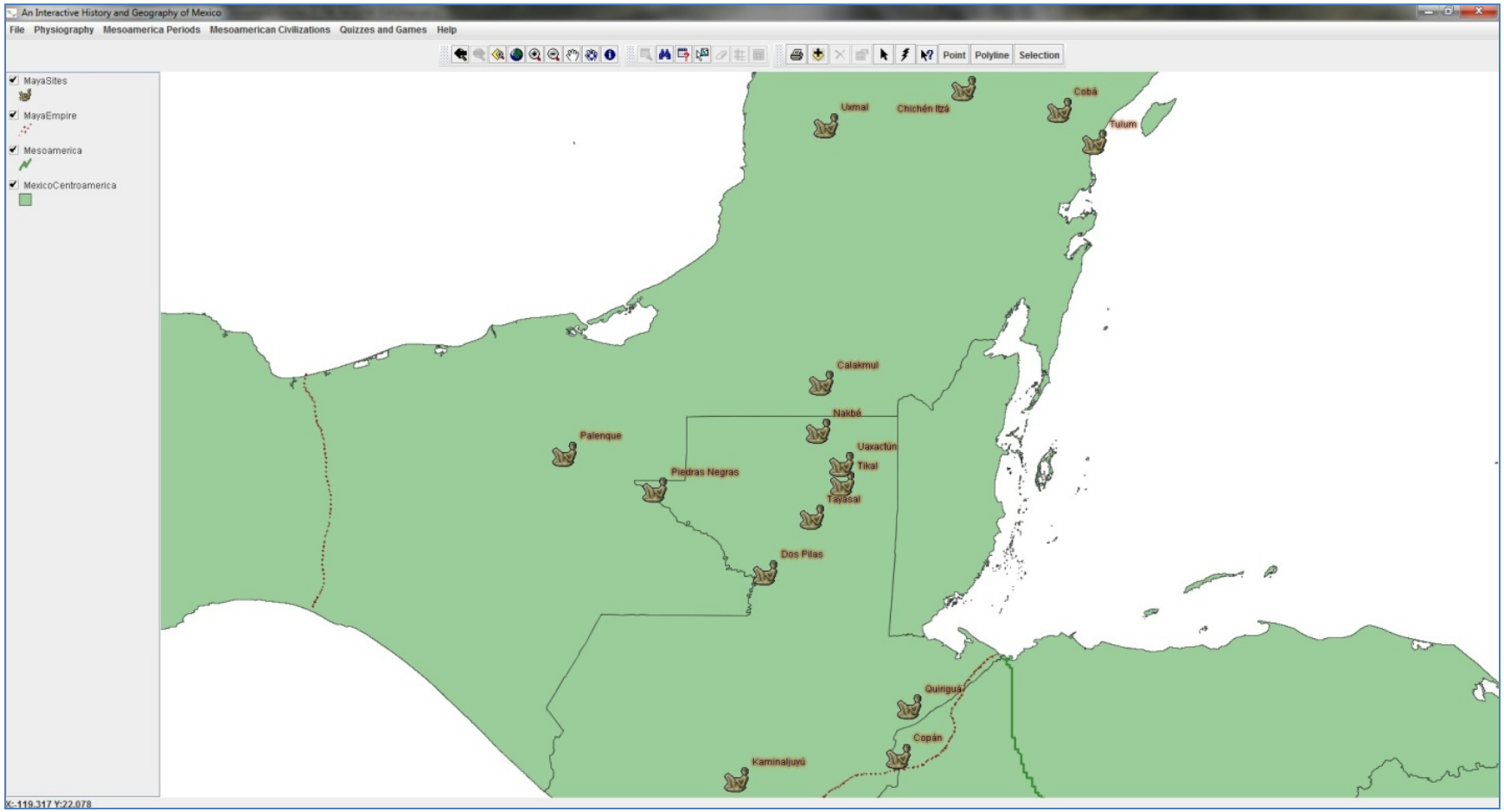



**Figure 5.68. Main sites founded by the Mayan Civilization.**

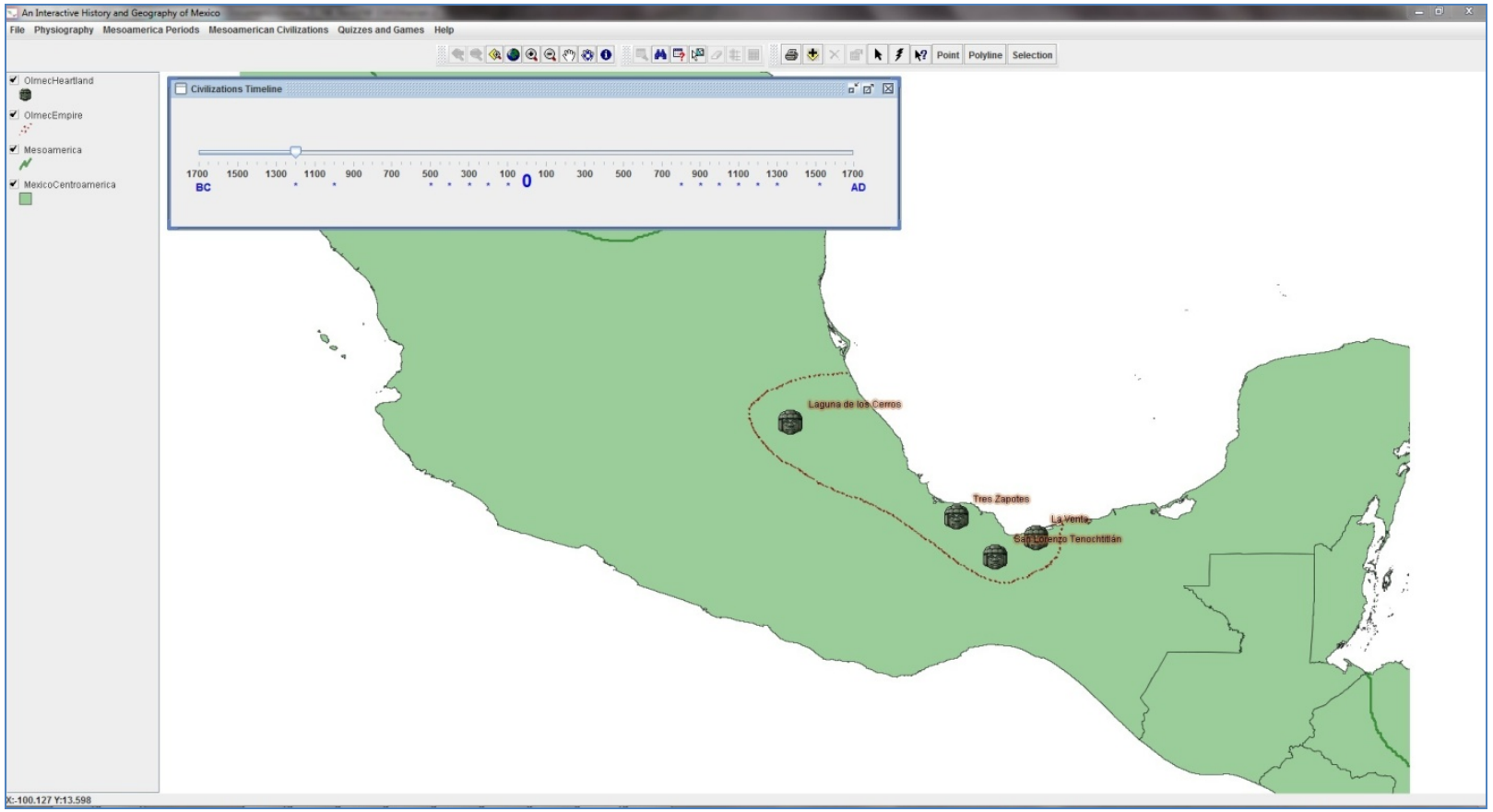



**Figure 5.69.Civilizations timeline (1200 BC).**

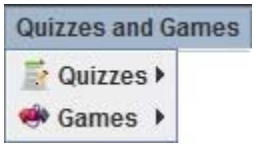



**Figure 5.70. Quizzes and games menu.**

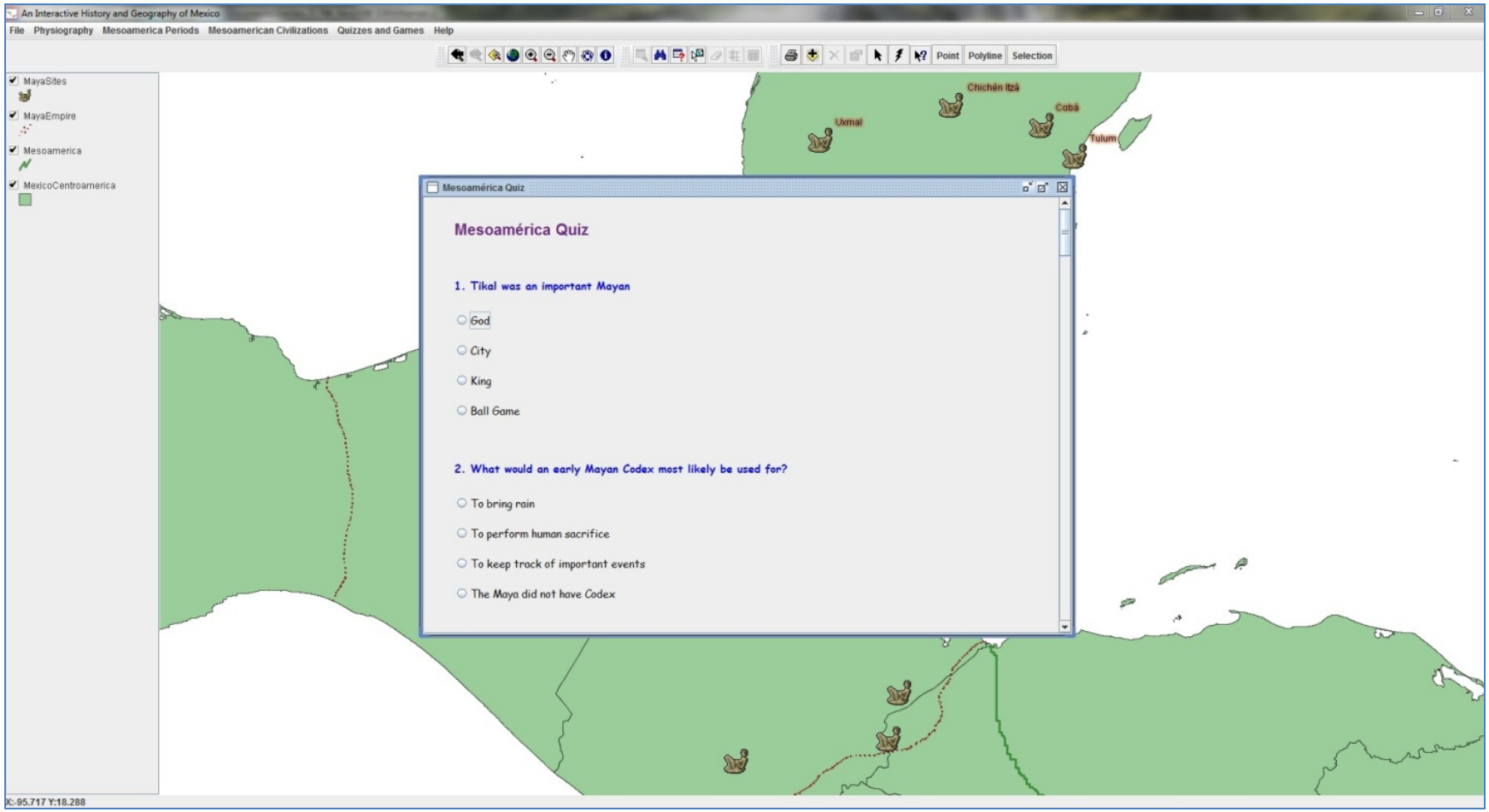



**Figure 5.71. Mesoamerica's quiz. General format for the quizzes on Mesoamerica's history. To get a score on the quiz an action button "Get Score" is provided at the end of it.**

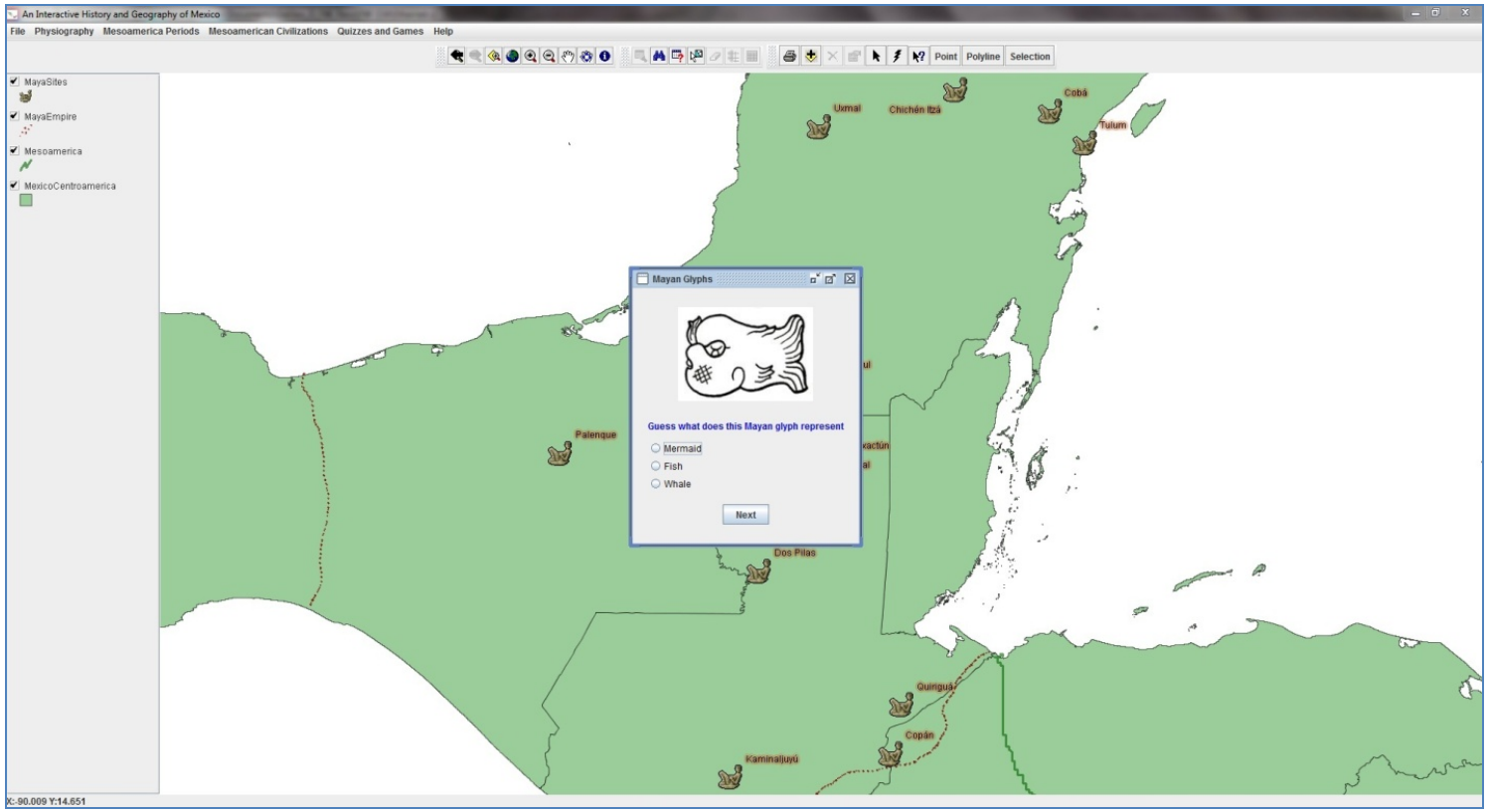



**Figure 5.72. Game on Mayan glyphs. The student has to guess what the Mayan glyph means.**

**Figure 5.73. Help menu.**

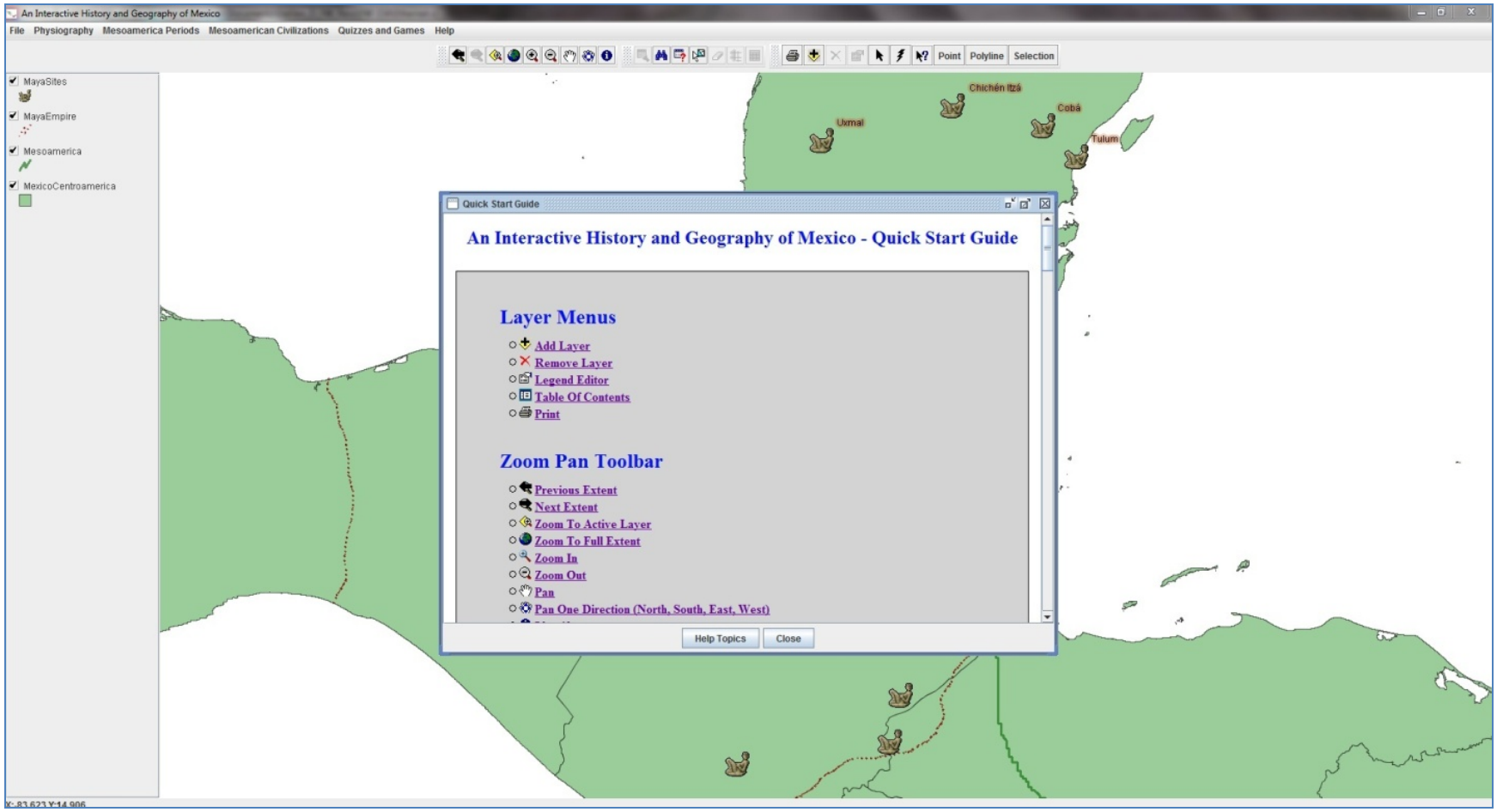



**Figure 5.74. Quick start guide for the application.**

# CHAPTER 6

# CONCLUSIONS AND OBSTACLES

This thesis work was extremely motivating for me, not only because one of the goals was showcasing Mexico's history, geography and culture but because the ultimate goal of this work was to provide the students of Mexico's history and geography, with an interactive tool that supports and enhances their learning process in today's world. I strongly believe that technology is going to be a central part (it already is in a lot of ways) of the education of the future, so to have been able to develop this tool is very fulfilling.

There were a lot of obstacles and difficulties to overcome during the development of this tool, mainly because I have not had a lot of experience with the two main technologies (Java and MapObjects) used for this project. For this same reason, I thought that the development time for some of the features was going to be shorter that it actually ended up being. But that is expected when dealing with technologies that you are not very familiar with.

The creation of some of the layers, especially the mountain ranges layer, proved a little more challenging than I expected. The GIS data was hard to find and drawing and rendering the ranges' borders took a lot of time and research within the MapObjects API.

Another difficulty that I encountered often was that some of the features and methods supported by the MapObjects API were buggy and it was hard to get around this. Even simple things like the location of feature's labels proved really frustrating when dealing with polygons, especially if these were considerably small (like in the case of the lakes map). The polygons would sometimes get lost underneath the labels. One would think that this is a small fix, and in theory it should be, but the methods and constants provided by the MapObjects API to do this, would not work at all. In my research for a solution, I found a lot of comments on this in the ESRI forum by many other developers with similar issues to mine.

The resizing of the maps was another frequent issue I had, especially because I applied different zooms to different layers and because I had two different base layers (the

Mexico's states map and the Mexico-Central America region map). Every time I had to change the zoom on a specific layer I had to update my map's extent so it would resize appropriately depending on the map currently displayed. Repainting the map's labels, when resizing, was also something that I had to implement. Because of some strange reason, that I never really figured out, the labels would sometimes disappear from the map when the size of the main application window was changed, so I had to make sure this never happened by repainting them every time a resize event occurred.

The learning curve for the Java layout managers, AWT and Swing, was not easy to take on. I got stuck many times trying to display GUI components in a certain way. Towards the end of the development it got significantly easier after I gained more understanding on how they worked.

Like I discussed in the last couple of paragraphs, the technologies used for the development of this project were sometimes challenging, but I really enjoyed this whole process because, among other things, it has opened to me the possibility of combining two things that I truly love: technology and history. To be potentially involved in interactive knowledge projects like this one, in the near future, paints a really exciting career path for me.

# CHAPTER 7

# FUTURE WORK

This thesis project leaves a lot of space for future work that could cover really diverse aspects of Mexico's history, geography and culture.

Some of the possible areas or features that could be explored or implemented are listed below:

In the geography area:

- Map layers on Mexico's biogeography that would deal with patterns of species distribution. It would be especially interesting to create layers that could show (present and past) geography distribution of animal and plant species.
- A Map layer on Mexico's desert geography.
- Map layers on climate trends that could show climate change in Mexico over a specific period of time.
- A map layer on the political divisions in Mexico that includes information on all of the state's capitals.

In the historic area:

- Continue to further extend the current layers on Mesoamerica's history and add new ones. Layers on the tribute network controlled by the Aztec Empire, trade networks between the different Mesoamerican sites, battles between empires, etc.
- Include layers on Mexico's Colonial History: The Conqueror's different expeditions, evangelization areas, battles against the indigenous people, etc.
- Mexico's Independence and Revolution layers: battles against the Spaniards (Independence), distribution of the different insurgent groups and civil war factions (Revolution), etc.

In the cultural area:

- A map layer on Mexico's main tourist sites.
- A layer on the different cuisine types across the different regions in the country.
- Distribution and information on the different indigenous groups.
- Information on the distribution of Mexico's industries, agricultural crops, imports and exports that support the country's economy.
- A layer with Information on the traditional dances for each region.

The amount of quizzes and games presented in this application could also be increased. In the case of the quizzes, the ability for the teacher to create a quiz could also be added by implementing the appropriate user interface that allows the input of questions, multiple options and correct answers. Given the modularity in which the Quiz class was created, this is easily doable.

The list of features could continue, showing this way that Mexico is a country rich in history, culture, traditions and biodiversity.

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